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ELECTRIC LIGHTING IN MILLS.

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[Read before the New England Cotton Manufacturers' Association, Oct. 25, 1882.]

Although the cruder forms of electric light were made early in this century, preceding the locomotive, the telegraph and illuminating gas, yet the mechanical refinements devised within a few years have been necessary to master many of the practical and economic difficulties, and render it feasible to bring electric lighting from the laboratory to the commercial world, creating an element in manufacturing affairs.

Although our object is to consider electric lighting solely in regard to its employment for industrial purposes, a better understanding may be reached by examining some of the principles involved in its production.

The accumulation of electricity by means of a dynamo machine is based upon two principles: First, that when a wire is moved across a magnet through the field of force, the power exerted against the attraction of the magnet is converted into electricity. Second, when an electric current is passed through insulated wires coiled around a piece of iron, the iron is magnetized.

In a dynamo machine the magnets are very feebly magnetized; but when the armature is revolved it generates an electric current, which

passes through the wires around the magnets, increasing their strength and enabling them to produce a stronger current in the armature, and this in turn adds to the strength of the magnets, the armature and the magnets reacting on each other until the limit of the capacity of the magnets is reached, after several hundred revolutions of the armature. When the motion of the armature is stopped the magnets lose nearly all their magnetism, as soft iron will not retain magnetism like steel.

Permanent steel magnets were originally used for this purpose; but electro magnets are capable of holding twenty times as much magnetism as permanent magnets.

This is the rough outline of dynamo machines. Their construction is not so simple a matter, involving numerous problems upon matters which cannot be considered here.

Electricity for lighting might be furnished by galvanic batteries, but the cost would amount to twenty-five times as much as when generated by a dynamo.

There are two methods of converting electricity into light. The arc light is chiefly due to the glowing of the tips of the carbons caused by the high temperature produced by the current overcoming the resistance offered by the space between the carbon poles, whereby the energy of the electricity is converted into heat.

The carbons are slowly volatilized and partially burned. The intensely heated vapor adds to the illumination, but the combustion of the burning carbon interferes with the light, as the arc light is more brilliant when enclosed in a glass receiver and removing the air. The incandescent light is produced by the current overcoming the resistance offered by a filament of carbon and raising it to a temperature sufficient to render it luminous.

The immediate destruction of the carbon is prevented by regulating the quantity of the current and enclosing the carbon in a glass bulb and exhausting the air, so that it cannot burn.

Both the arc and the incandescent light is due to the glowing of intensely heated carbon. In the arc light the incandescence is destructive to the carbon; and in the incandescent lamp the object is to make the carbon as enduring as possible under the conditions of brilliancy, which are essential for satisfactory results. The arc lamps are placed at openings in the conducting wires, and the carbons form a portion of the circuit. The electricity passes through the lamps in order, and the tension is reduced a certain amount at each lamp.

In the incandescent system the lamps are hung in wires swung down from the main conductors, so that the current is divided, an equal portion passing through each lamp. The comparison is sometimes made that the main conductors could be represented by the sides of a ladder, while the position of incandescent lamps would be in the middle of the rounds of the ladder.

In the arc light, where the carbon is heated to destruction, the total quantity of light for a given expenditure of electricity is about nine times what it is in an incandescent light working at a commercial rate. In an incandescent lamp the question of endurance of the carbon is the second factor in determining the most advisable brilliancy for the light.

According to Howell's experiments on the Edison light, if the electricity supplied to a 16 candle power Edison lamp be increased one-fourth, the candle power is doubled, but the endurance of the lamp would be reduced.

The golden mean of the true economy between expense of renewals of lamps and that of power can be reached only by long experience.

I presume that the present intensity of brilliancy which has been adopted is at about the minimum cost for the present construction of carbons.

The unit of measurement of light is expressed in candle power, which is the light furnished by a standard wax candle burning 120 grains per hour. The candle power of burning gas is the light given by an argand burner consuming 5 cubic feet of gas per hour.

With the incandescent lamp the light is nearly uniform in all directions.

In the arc light the terminals of the carbons are different, the lower carbon consuming to a sharp point, and the upper one is blunt and the end concave. The light emitted from these ends is not alike; the upper carbon having the most heated surface, about nine-tenths of the light is thrown downward below a horizontal plane. The power of arc lights, as generally stated, is that of the strongest rays which are thrown down at an angle of 45 degrees, which is about twice the brilliancy of the average light. Nearly half of the light is held back by the white glass shades, and the arc lights being further apart an excess of light is necessary to secure sufficient diffusion at extreme points, because the intensity of light diminishes as the square of the distance.

The value of electricity for lighting mills is based upon the charac-

ter of the illumination desired, each mill being, to some extent, a law unto itself.

One of the first items of consideration is the influence of electric light upon the opertive, considered as a machine to be kept in good condition, in order to obtain the best results. As the electric light does not require any air to support combustion, it does not injure the air in a mill.

On the other hand, Dr. William A. Hammond states:* "A gas burner consuming four cubic feet per hour produces more carbonic acid gas in a given time than is evolved from the respiration of eight adult human beings."

This is an important matter in night work, when the air becomes so impure that it prevents the operatives from doing the amount of work which they could do if the air was pure.

Gas lights increase the temperature excessively. In the basement story of a mill 400 by 65 feet, and 15 feet high, were 456 looms on heavy colored cotton goods. The room was lighted by 457 four-foot gas burners. When these were used it was stated that the temperature increased 25 degrees in an hour. Now the room is lighted by 35 electric lights, and the increase in temperature, if any, is not enough to be indicated by an ordinary thermometer. In two other mills the rise in temperature, after lighting the gas, varied from 11 to 13 degrees.

The economy of any light increases much more rapidly than the temperature. A large gas light furnishes more light for a given quantity of gas than a small one.

† Nine years ago I made some experiments upon the efficiency of kerosene burners, and obtained similar results.

The temperature of the upper carbon ‡ in an electric arc light is estimated at 6000 degrees Fahrenheit, and the lower one at 4500 degrees, but this estimate refers only to the special light experimented with, which were used small carbons, and the general result to-day is probably greater than the one given above.

This high temperature furnishes much more light rays from a given amount of heat than a lower temperature would give.

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* *Our Continent*, March 8, 1882.

† JOURNAL FRANKLIN INSTITUTE, August, 1873.

‡ *Journal de Physique*, August, 1879.

Dr. Chas. W. Siemens, in an address delivered before the British Association in York, England, last August,* stated that in a gas burner only one per cent. of the calorific energy of combustion produced light; while in the incandescent light it was three and seven-tenths per cent., and in the arc light it amounted to thirty-three per cent. Whether subsequent investigation may not modify these results is an open question, but the general statement that the electric light contains a much smaller proportion of the heat rays than gas will be questioned.

It is stated by Mr. W. H. Pickering† that the injurious effects of artificial light upon the eyesight are due to heat from lights, and not to the light itself.

Another matter of value in electric lights is the ability to distinguish tints. The light from the tips of the carbons is white, and the light of the arc between them is a bluish-purple, so that the general tint of the arc is that bluish-white, which has a very white appearance.

Where the use of shades of color is involved, electricity furnishes the only artificial light which can be feasibly used; and in such cases where the operation of a certain department would otherwise be limited to the duration of sunlight, the economy from the use of the electric light is, to a certain extent, proportionate to extra profits accruing from this extension of the time of labor.

In other departments of manufacturing, the aid to the production of perfect work, by this improved illumination, is a source of additional revenue, because the proportion of damaged goods usually made when the mill is badly lighted is thereby diminished.

Expense.

The cost of maintenance of a system of lighting bears little relation to its intrinsic worth. The item of cost of lighting is a small fraction of the whole operating expense, and what is desired is to light a mill so well that there will be no difference in the character of day and night work, either in quantity or quality. Any expenditure beyond that is unwarrantable.

The question of the cost of lighting by electricity is subject to many legitimate variations, of which the question of power is most variable.

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* *Engineering*, September 1, 1882.

† *Nature*, February 9, 1882.

In a steam mill, where the dynamo is driven by the same engine that runs the mill, it should only be charged with its share of fuel, but not with any other expense of power, wherever it does not introduce any new expenditures in the way of plant, repairs, or labor in the engine room.

Some mills have departments which are only run by daylight, where work is thrown off at sundown, and so compensates for the steam required by the dynamo. For example, in one mill using electric lights, the power used in the nepping room is slightly more than is required for the dynamo, so when the machinery in that room is stopped, the dynamo can be started without bringing any extra load on the engine. Most factories are driven by water power, with supplementary steam power during low water in the summer months; the electric lights would be required during the shorter days of the year at a time when there is usually an abundance of water, and the extra power can be used by the dynamo by the use of more water, without requiring any additional expense.

It is difficult to make a comparison between various methods of illumination, because a change of light is always made an excuse for more light.

The majority of mills are lighted with gas made by the destructive distillation of petroleum, and of about 80 candle power, which is generally reduced to 60 candle power by mixing air with it, and burned through one foot (nominal) burners, which consume about one and a quarter feet per hour.

The annual cost of oil gas per burner is from seventy-five cents to one dollar. In all these estimates, interest at six per cent. forms one item in cost. One large corporation, with exceptional privileges, makes its coal gas at an annual cost of 69 cents per burner. Another corporation, inland, makes its coal gas at $1.25 per thousand cubic feet, at an annual cost of $1.79 per burner, each burner consuming 1433 cubic feet annually.

Of two large mills in the same city, manufacturing similar goods, the more modern one makes oil gas at an annual cost of 79 cents per burner, while the older one buys coal gas at $2.65 per burner.

Sometimes when the gas making apparatus is not managed with skill, the goods are damaged from soot which settles on them.

The longer time light is required, the average cost is lessened, because with the addition of operating expenses, the interest on plant, being a fixed amount, becomes a smaller proportion of the whole cost.

In electric lighting, the cost of plant is so much that interest is an important item, and when a mill is run nights, the relative cost of electric lighting is materially diminished. A white cotton mill, running 60 hours a week, generally uses light 300 to 350 hours a year; where they run 66 hours a week lights are required 400 to 450 hours a year. A dark mill requires about twice the number of lights that is sufficient in a white mill, and uses light about 100 hours a year more than a white mill.

An arc light, as generally used in mills, requires about one horse-power. Mr. James Renfrew, Jr., at Adams, Mass., has found, by test, that the 40 light Brush dynamos in his mills each require 36·6 horse power. The lights were running in a satisfactory manner, but no photometric tests were made.

The cost of arc lights in several steam mills running 400 hours per year, is 6½ cents per hour, of which 1½ cents are for carbons, and 5 cents for attendance, coal, depreciation and interest. When a mill runs nights, the hourly cost is diminished.

The ratio of substituting electric lights for gas, is quite variable, being one arc light to from ten to twenty gas burners. In one mill lighted by kerosene the ratio was one arc lamp to eight kerosene lamps.

In a colored mill, one arc light will light the looms on 700 to 1400 square feet of floor, but in a white mill the same light will be sufficient for looms on 1000 to 2000 square feet of floor. The reflected light from white walls and ceilings adds very materially to the diffusion.

A card room 48 by 100 feet, containing 64 cards, was satisfactorily lighted by one arc light. The end of the room was extended about 40 feet, and the light was not satisfactory toward that end of the room, because there was no end wall to serve as a reflector.

It is convenient to compare the cost of electric lighting with the expense of gas in the same place, although it must be remembered that gas does not furnish as much or as good light, and is therefore not so valuable where quality of light is of importance.

In a weave room, on very fine work, 24 arc lights replaced 292 six foot burners, which consume (292×6) 1752 feet per hour, so one arc light represents the consumption of ($1752 \div 24$) 73 feet of gas per hour. A careful estimate shows these arc lights to be costing 6½ cents an hour, so this arc lighting system represents gas at 89 cents per thousand. A similar estimate in another mill gives the annual cost of gas

$2188, and electricity at $1125, or equal to gas at 90 cents a thousand. The annual saving to that mill in lighting expenses by the use of electricity makes a profit of $1603, which represents 6 per cent. on $17,716, without making mention of any improvement in work or production due to that light. In both of these establishments the lights were used about 450 hours per year. Other estimates give the cost of arc lighting equal to gas at from 65 cents upward per thousand. In the case of incandescent lighting the cost is more difficult to estimate, because they are run at all degrees of brilliancy, affecting both the power and the life of the lamp.

Both the Edison and the Maxim lamps are guaranteed to average 600 hours; yet in the New York post office the average record of the Maxim lamps is stated to be 1850 hours up to September first, and 15 lamps had already burned 3456 hours.

The ferry boat Jersey City, belonging to the Pennsylvania Railroad, is lighted by the Maxim lights, and their record has been given to me as averaging 1645 hours, and the lamps still burning.

The data for the above was taken with lamps in use, and does not represent their ultimate endurance.

Mr. Timothy Merrick, of Holyoke, authorizes me to give the facts respecting his experience with the Edison system in the Merrick Thread Company's mill, number 3. This mill runs all night five nights in the week for fifty-one weeks per year, using light 2869 hours per annum. It was lighted by 95 burners with city gas, costing $2.13 net, which amounted to $225 per month. 95 Edison B burners (8 candle power) were substituted for the gas. In the first 1000 hours five lamp carbons had broken, and October 20th they had been in use 1278 hours, and 11 had broken.

Allowing that the lamps average six months' use, the cost of lighting is made up as follows:

190 lamps, at $1, . . .	$190 00
Interest and depreciation, . .	153 50
6 h. p., at $10, ...	60 00
Annual cost Edison light, . .	$403 50
Monthly " " . . .	33 62
Monthly cost gas, . . .	225 00

The results from these lamps are very satisfactory, and certainly in

excess of what would have been obtained if the lamps had been forced beyond their normal capacity.

The Holyoke Water Power Company furnish water power very cheaply; and the result may be interesting if we hold the Edison Company to their minimum guarantee; and also charge the dynamo with four pounds of coal per hourly horse power.

4·78-100 renewals of 95 lamps equals 454 lamps, at $1.00,	$454.00
Interest and depreciation, ...	153.50
30·74 tons coal, at $5.75, ...	176.81
Annual cost Edison light, ...	$784.31
Monthly " " " . . .	65.36

Which is equal to gas at 65 cents per thousand.

The mill is situated at the base of a high bank, and is only eleven feet, six inches between floors, so it is very hot in summer, and Mr. Merrick informed me that it would have been impossible to run the mill nights during the extremely hot season last summer, if the help had been subjected to the heat and vitiated air from the burning gas.

It must be kept in mind that an instance of a mill running day and night is an extreme one in favor of the electric lights; but the data are given and the matter can be estimated to suit other times of operation.

If these electric plants were charged the proportionate cost of power, besides coal, the cost would be estimated greater than stated above.

Improvements.

The question is frequently asked, will there not be improvements in electric apparatus, so that the light will be furnished for less cost and power. Of course there will be improvements, but it seems as if they would refer to attachments rather than the more permanent portion of the apparatus. The dynamo machines are the most perfect instruments, as they convert 80 to 90 per cent. of the motive power into electricity delivered at the conducting wires. It will be found essential that all dynamos have current governors which regulate the supply of electricity in proportion to the demand, without waste of energy.

There does not seem to be any demand for a change in the system of wiring.

In the arc lamps there is urgent need of better carbons, and in the incandescent lamp there is a demand for the highest qualities of endurance and electrical resistance.

These are all matters of detail, and except the first, refer to portions which are subject to continual renewal.

The so called "storage" of electricity is a subject which is the object of much interest. Electricity alone, of all forms of energy, is used from hand to mouth, so that the dynamo must be equal to the greatest demand upon the system at any one instant.

All forms of electric lights require uniformity in the speed of the dynamo and the incandescent lights are especially sensitive to variations in the speed, so that it is frequently advisable to have a separate engine solely on that account. Such uniform speed would not be essential for the dynamo used in charging secondary batteries.

In a storage battery, the electricity is not accumulated in any manner, as is sometimes assumed, but a certain chemical action is produced by passing an electric current through the battery, and later on a counter-chemical action produces electricity, when the battery is discharged.

The Faure storage battery consists of sheets of lead, coated with red-lead and covered with sheets of felt. The whole is enclosed in a box, and covered with dilute sulphuric acid. On passing an electric current through the battery, the red-lead on the negative side loses its oxygen, which combines with the red-lead on the positive side, the result being that one coating of red-lead is reduced to pure lead, and the other side changed to peroxide of lead. When the battery is put in use, the theory is that this atom of oxygen leaves the peroxide of lead on one side, and rejoins the spongy lead on the other side, producing the secondary current; but difficulty has been experienced from losses due to various kinds of local action in the battery, such as the deposition of sulphate of lead, and the injury to the sheets of felt, so that the electricity regained has not been as much as is desired.

There are several forms of secondary batteries, all of which are similar in principle; and one free from the faults due to local action would be a great boon to all users of incandescent lamps, for then the apparatus would be permanent, and its efficiency such that would insure commercial success.

Safeguards of Electric Lighting.

The experience of the insurance companies, in regard to electric lighting, has constituted the subject a factor in underwriting. It is difficult to estimate the amount of hazard to which property is sub-

jected by its use, because the elements of danger are diminished by suitable precautions. The hazards attending the use of the electric light have been over-estimated; not in numbers or magnitude, but because too little account has been given to the preventable nature of such occurrences. If these precautions are disregarded, only good luck will avert disaster.

It is sometimes assumed by those ignorant of the facts that electric lighting apparatus cannot set a fire. Electricity is no exception to other forms of energy. All power can be converted into heat.

Your mills are equally liable to hot bearings, whether the motive power is derived from the fires under the boilers, or to the head of water in the mill pond.

Whenever anyone states, as a principle, that the electricity used for lighting cannot set fire to anything he is not only in error, but is uttering a fallacy which will lead to the destruction of property, if carried into effect in any electric lighting system.

It is better to meet the issue fairly, and the interests of all will be advanced by the consideration of its dangers, for in no other manner can suitable measures for protection be reached.

In the Mill Mutual Insurance companies there were sixty-one establishments lighted by electricity up to last May.

With few exceptions, the lights had not been in use previous to the autumn of 1881, and many had been started early in the spring.

In these sixty-one establishments I know of twenty-two fires due to electric lighting and assignable to the following causes: eight were from globules of melted copper, or particles of hot carbon falling out from the bottom of the globes. The actual number of fires from this cause was probably many times this number. That class of fires will not continue to happen, as all makers now set their lamp globes in a tight stand with a ridge around the edge. A flat plate will not answer the purpose, as there was one instance where drops of melted copper rolled off and set a fire.

Four fires were due to leaking water or washing floors, and two more were caused by water in a dye-house condensing on the building to which uninsulated wires were fastened. In most of these instances a grounded circuit formed one of the two connections necessary to divert the electricity from the wires. Many of the lower carbons fell from lamps, and five fires were caused where they fell upon combustible material. Three fires were caused by cross arcs from one wire

to another, where uninsulated wires were fastened against conductors. In one instance the conductor was formed by dust settling upon uninsulated wires, and on a damp day it absorbed enough moisture to form a path for the formation of a cross arc, which started a slight fire.

In another instance, the wires were fastened to a damp beam, which was decayed, and was burned nearly in two by the smouldering fire. And in the third instance, damp brickwork in a tunnel was a sufficient conductor to establish an arc which did not do any material damage there, but injured the dynamo. Other fires produced by cross arcs started by water, forming a connection between two wires, have been referred to.

In my connection with electric lighting matters for the Underwriters' Union I know of two fires caused by improper switches; two by water reaching the wires of a circuit already grounded, and one from wires coming in contact with a building, so that their insulation was worn away.

I believe that all these fires should be classed as avoidable fires, because the use of well-known precautions would have anticipated their possibility.

The precautions are known only as a matter of experience, because there was no source of information stating the results from electric lighting currents under certain circumstances.

The damage from these fires was in each instance small, as would be expected. It is the experience of the Boston Manufacturers' Mutual Fire Insurance Company that in mills three-fourths of the fires are in the daytime, and three-fourths of the losses are in the night; so the chance of loss in the night is nine times as great as in the day. During the last two years the introduction of automatic sprinklers has reduced the damage from night fires one-half.

As the electric lights are used during working hours, these accidents come under the head of day fires. When they have happened, there has always been a sufficient number of employés engaged on the premises to attend to the matter at once. When electricity is diverted from the system, the lights are correspondingly diminished, and general attention directed to the difficulty.

Eyre M. Shaw, Captain of the Metropolitan Fire Brigade of London, when in Boston, during his recent visit to America, stated to me that since the introduction of the electric light there had been about one hundred fires in London from this cause.

Electricity forms the safest method of illumination when the following precautions are observed: The system insulated throughout, so that there is no electrical communication with the earth or from one part of the apparatus to another, except through the proper conductors, even if the wires should be exposed to water. All switches made with a lapping connection, so that no arc can be formed. Arc lamps provided with globes closed underneath, and the frame so arranged that the lower carbon could not fall out, even if the clamp failed to hold it securely.

The wires of incandescent systems provided with a sufficient number of fusible links to secure the system against any damage from an excess of current.

The carrying out of these principles in every detail requires careful work and constant watchfulness.

Other features in an electric lighting system are advisable to assure the most satisfactory operation of the apparatus, but they are not essential to secure safety against fire.

The insulation of a system can be assured only by frequent tests. The best instrument for ordinary use is a magneto, which generates an alternating current and rings a bell, like the ordinary telephone "calls." It is used by connecting one wire to the ground and the other to the system. The presence of a fault is indicated by the ringing of the bell when the magneto is put in operation. Means for the systematic trial of the insulation is relatively as important as the use of gauge-cocks on boilers.

If an electric lighting system is sufficiently insulated when first arranged there is no assurance that it will remain so, on account of the numerous changes, blunders, and accidents to which it is subjected, Unfortunately we are not forewarned of any lurking disarrangement of electric apparatus by means of any of the senses, in the same manner that leaking gas appeals to the sense of smell, or as leaking steam produces sound and vapor.

When electric lights become dim in rainy weather it is conclusive evidence of ground connections, which divert the electricity from the system, causing both commercial loss of electricity and great danger of fire. Two contacts are necessary to divert electricity from an electric lighting system. If one contact already exists and connects it with the earth, only one more contact is necessary to conduct a portion of the electricity from the system.

In such an event, if the electricity meets with a conductor of sufficiently high resistance, the electricity is converted into heat sufficient to burn any combustible substance which is present.

Underwriters have two methods of defence against a special hazard: the one to advance the rate to an amount deemed commensurate with the increased danger, and the other method consists in the removal of the source of danger.

With electric lighting the hazard is not an inseparable part of the system, can be obviated by the measures which have been referred to, which are applicable to all systems of electric lighting.

In preparing the Regulations for the Fire Underwriters' Union* I did not ask for any precaution not found by the experience of accidents and actual fires to be essential to protect either person or property.

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*Regulations of the Boston Fire Underwriters' Union for the Use of Electric Lighting Apparatus.—Wires.—Conducting wires over buildings must be seven feet above roofs, and also high enough to avoid ladders of the Fire Department.

Whenever the electric light wires are in proximity to other wires dead guard wires must be placed so as to prevent any possibility of contact, in case of accident to the wires or their supports. Conducting wires must be secured to insulated fastenings, and covered with an insulation which is water-proof on the outside and not easily worn by abrasion. Whenever wires pass through walls, roofs, floors, or partitions, or there is liability to abrasion, or exposure to rats and mice, the insulation must be protected with lead, rubber, stoneware, or some other satisfactory material. Wires entering buildings must be wrapped so that water cannot enter through the tubes.

For inside use, loops of wire must be avoided, and the insulating fastenings arranged to keep the wires free from contact with the building.

Joints in wires to be securely made and wrapped. Soldered joints are desirable, but not essential. Wires conducting electricity for arc lights must not approach each other nearer than one foot, and for incandescent lamps the main wires must not be less than two and a half inches apart.

Care must be taken that the wires are not placed one above another in such a manner that water could make a cross connection.

A cut-out which can be operated by the firemen or police must be placed in the circuit in a well protected and accessible place.

Lamps.—For arc lamps, the frames and other exposed parts of the lamps must be insulated from the circuit. Each lamp must be provided with a separate hand switch, and also with an automatic switch which will close the circuit and put out the light whenever the carbons do not approach each other, or the resistance of the lamp becomes excessive from any cause. The lamps must be provided with some arrangement or device to prevent the lower carbons from falling out, in case the clamp should not hold them securely.

For inside use the light must be surrounded by a globe, which must rest in a tight

The effects of an electric lighting current upon the person bears no relation to the injury which that current can do to property. Electricity has the two properties of quantity and tension, which are independent of each other; the heating effects are due to the quantity, and the results upon the person are proportional to the tension of the electricity.

However, the greater the tension, the more liable is the electricity to force its way through bad conductors. The arc light is produced by a current of high tension and small quantity; the incandescent light is formed by a current of low tension and great quantity.

Therefore, in the arc light system, the most secure insulation is essential; but with incandescent lights, if the insulation were ineffective, there would be more liability of fire. In incandescent lighting systems the whole reliance for safety is not placed upon the insulation, but small fusible links are placed at various points in the wires; so that, if the quantity of the current exceeds a certain amount, the fusi-

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stand, so that no particles of melted copper or heated carbon can escape; and when near combustible material this globe must be protected by a wire netting. Broken or cracked globes must be replaced immediately. Unless a very high globe is used, which closes in as far as possible at the top, it must be covered by some protector reaching to a safe distance above the light.

For incandescent lamps, the conducting wires leading to each building and to each important branch circuit must be provided with an automatic switch or cut-off, or its equivalent, capable of protecting the system from any injury due to an excessive current of electricity.

The small wires leading to each lamp from the main wires must be very thoroughly insulated, and if separated or broken, no attempt made join them while the current is in the main wires.

Dynamo Machines.—Dynamo machines must be located in dry places, not exposed to flyings or easily combustible material, and insulated upon wood foundations. They must be provided with devices capable of controlling any changes in the quantity of the current; and, if these governors are not automatic, a competent person must be in attendance near the machine whenever it is in operation.

Each machine must be used with complete wire circuit; and connections of wires with pipes, or the use of ground circuits in any other method, is absolutely prohibited.

The whole system must be kept insulated, and tested every day for ground connections at ample time before lighting to remedy faults of insulation, if they are discovered.

Preference is given for switches constructed with a lapping connection, so that no electric arc can be formed at the switch when it is changed; otherwise the stands of switches, where powerful currents are used, must be made of stoneware, glass, slate, or some incombustible substance which will withstand the heat of the arc when the switch is changed.

ble link will be melted, and cut off the electricity before other damage could ensue.

Although these safety-catches were originally devised for the purpose of protecting the carbon filaments of incandescent lamps from destruction by extra currents; yet they are essential to assure safety against fire, and it is the use of these safety-catches, and not from the fact that the electrical portions of the system can be handled with impunity, that has given the insurance interests somewhat of a bias in favor of incandescent lighting.

Electric lighting should be encouraged on account of its inherent qualities of safety. Any system that is in conformity to the insurance regulations is also in its best condition electrically.

Electricity, like all forms of energy, is dangerous to the extent that it is not held in control. The same is true of steam in boilers, or water in mill ponds. Like fire, they are all "good servants but poor masters."

Electric Resistance of a Vacuum.—Edlund after repeating and discussing the various experiments upon the non-conductibility of a vacuum finds no evidence that the obstacle to the passage of electricity exists anywhere except in the electrode. He calls especial attention to the resistance which Hittorff pointed out, at the negative electrode, and which De la Rue and Sarasin also observed in their researches relative to the action of magnetism upon the electric discharge in rarefied gases. The proper resistance of the gas diminishes constantly with the pressure of the gas until that pressure has descended to a small fraction of a millimetre. At the same time the resistance to the passage of the current from the gas to the solid electrode continually increases. No good reason has ever been assigned for supposing that these tendencies change their character. It is, therefore, most philosophical to conclude that a vacuum is a good conductor of electricity. Perhaps it would be better to say that electric currents can be propagated with so great facility in a vacuum that the notion of conductibility is deprived of all physical meaning; different material bodies simply produce a resistance more or less great to the propagation of electricity. Their effect in this respect is not active, but pasive.—*Mém. de l'Acad. de Suède.* C.

BRICKS AND BRICKMAKING MACHINERY.

By CYRUS CHAMBERS, JR.

[A paper read at a stated meeting of the Franklin Institute, December 20, 1882.]

Brickmaking is much more of an art than is usually supposed, and one that has perhaps made less progress than any other.

Bricks are made to-day in many localities much after the manner in vogue among the Egyptians.

True, the increased hardships enforced by their task-masters induced them to try making bricks "*without straw*," and had it not been for this circumstance we might have been making bricks with chopped straw to this day.

Bricks are indicative of the character of nations. Show me the brick of a people, and I will tell you much of their habits, manner of living, their climate, the burthens of their government, and the shrewdness with which they build.

The honest "Friends" of Philadelphia make their bricks to appear just what they are. Their size is convenient for handling, and the building of walls the full thickness specified, and they are proportioned without a desire to make each brick count in height of wall only.

Their "front" or "face-bricks" are not an inferior article painted over, in imitation of something better, but the genuine article, of a beautiful cherry color, and a surface texture of velvety softness that does not reflect the glare of the sun to a painful degree, as do the enameled and other completely vitrified surfaced bricks. The latter may be profitably used externally for ornamental purposes and internally where cleanliness, durability, or ornament make them desirable.

"Philadelphia press brick" are unapproached in richness of color, softness of texture, uniformity of shape, and durability. I use the term "Philadelphia press brick" to designate those made from the best of clay, impregnated with iron, extending from Virginia through Maryland, Delaware and Pennsylvania into the western portion of New Jersey.

It is said in some parts of the United States that a brick seven and one-half inches long and three and one-eighth inches wide will make just as good a "nine inch wall" as the Philadelphia size of eight and one-half by four inches, but I notice that there is no diminution in the

thickness of the bricks, the way they measure in height of wall. They often measure from one-half to five-eighths of an inch in thickness more than ours. Usually the shrewder a people, the smaller and proportionately thicker are their bricks, while the less cultivated use those of larger dimensions, as to length and breadth, but much thinner.

In parts of South America the bricks are from ten to twelve inches wide and eighteen to twenty inches in length, and sometimes only two inches thick. Cuban bricks are a mean between these extremes.

Where there is an "excise duty" upon bricks it exercises a great influence on their size. Then a thousand brick that will build the most wall will command the market.

The manufacture of brick by machinery has been a trying problem to the mechanical engineer.

Brick clays, usually composed of but a small percentage of alumina and a very large proportion of sand, gravel and stones, etc., are antagonistic to machinery, hence the short life of most brick machines.

Although bricks are a common looking commodity, they must possess certain qualities, such as ability to withstand the weather and the hardships of transportation; they must be of the required strength, must cut under the trowel, allow the mortar to adhere, absorb moisture to a certain degree, and withall be cheap. A "front brick," in addition to the above, must be of good surface texture, uniform in size, shape and of a pleasing and uniform color. To produce, by machinery, from rough, indifferent materials, a manufactured article possessing the above qualities is no easy task.

I have labored faithfully twenty years to accomplish this, and with what degree of success I leave you to judge.

During the past season there has been manufactured by our machinery alone, in and near Philadelphia, about *fifty millions* of bricks, at a cost so far below that of making by hand that I hesitate to state it, lest you would think me wavering from the truth. I have before you a *working machine* of one-fourth size, which we will put in operation, and I assure you that I can, with much less care, and greater ease, produce from eighty to one hundred *full sized* bricks per minute, from crude clay, direct from the bank, stones and all, than I can these little ones. This machine has not been dreamed out, or stumbled upon by accident, but is the result of twenty years of study, close observation, and many costly experiments; its parts are all simple, and admirably adapted for working in rough material. The parts that are

subject to great wear by the clay are made of hard iron or steel, fitting together without finish, and may be renewed at trifling cost, thus enabling the brickmaker to always keep the bricks of uniform size and shape, and to produce brick of as good quality at the end of ten years as when the machine was new. This machine is without "moulds" (in the ordinary acceptance of the term), has no reciprocating plungers to grind out, no cams or toggles to wear, but its principal movements are continuous and rotary, and move with an ease and rapidity unprecedented in the history of brickmaking machinery. The general plan of the machine for clays of ordinary qualities is:

1st. A tempering or *pugging device*, by which the clay is ground with water into a stiff plastic mass.

2d. An expressing device, by which the tempered clay is forced out with great force—say with a pressure of fifty tons, on the end of the brick.

3d. A forming device, by which the issuing clay is made to take the desired size and shape of a brick in cross section, but continuous in length.

4th. A sanding device, by which the surface of the issuing bar is coated with fine sand, to improve the surface texture and color, and prevent them from sticking together in the subsequent operations.

5th. A cutting-off device, by which the issuing bar is severed into uniform brick lengths with smooth ends and sharp corners.

6th. An off-bearing apparatus, by which the daily product of one hundred tons of soft manufactured material may be carried five hundred feet, if desired, ready for the further process of drying and burning.

The details of these various operations can best be understood from the diagrams on the screen, and an inspection of the operation of the machine.

Fig. 1 is a prospective view of our brick machine as erected for working ordinary clays, without the use of the stone extractors or clay elevators and mixers.

You see how the clay is fed to the machine direct from the cart and the water put in with it.

Here it is mixed and tempered, then expressed by the gimlet-pointed screw. The round column of clay is brought up square with an excess of clay forced into the corners; the bar then passes through a chamber, containing sand, and finally the spiral steel blade severs

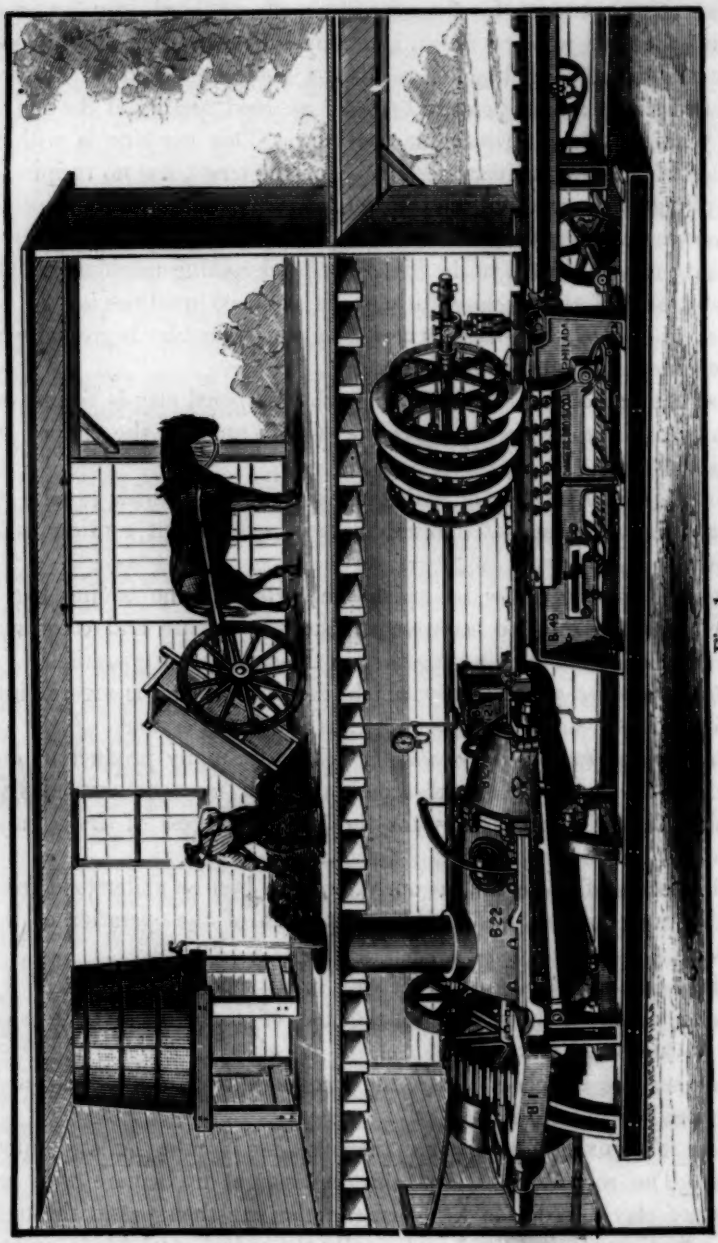

Fig. 1.

the bar into bricks with a long drawing cut, rubbing out its chip and smoothing the end of the brick.

The bricks are then off-borne to the yard to be loaded on drying cars or placed in the hacks for drying. No sun drying is necessary.

Fig. 2 is a horizontal sectional view of the machine, showing the tempering device, and the conical expressing screw. This screw runs in its steam-jacketed and fluted case, which prevents the clay from revolving with the screw, but facilitates its sliding forward, whereby it is "unscrewed" from off the end of the screw, and is forced into the forming die, when it takes shape and issues a "brick-bar."

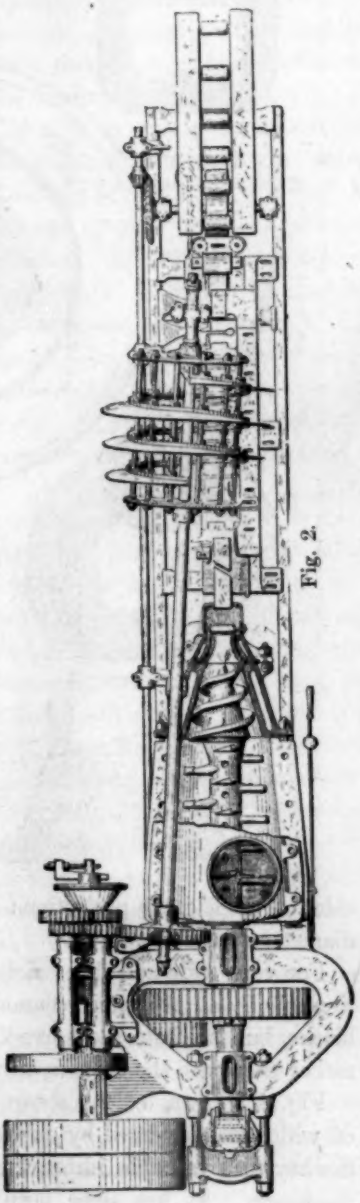

Fig. 2.

Fig. 3 represents the *forming-die* held within the steam-heated former case. Plastic materials, moving under pressure, follow the laws of fluids.

The great difficulty heretofore experienced in machines expressing plastic materials has been to make the flowing mass move with uniform velocity through all its parts. As the channel of a river flows faster than the shallow portions, or those near the banks, so does clay move through a die, the friction of the corners holding them back, while the center moves more freely. I overcome this difficulty by the peculiar form of the "former," which you see is so shaped as to facilitate the flow of the clay to the corners, and retard it opposite to the straight

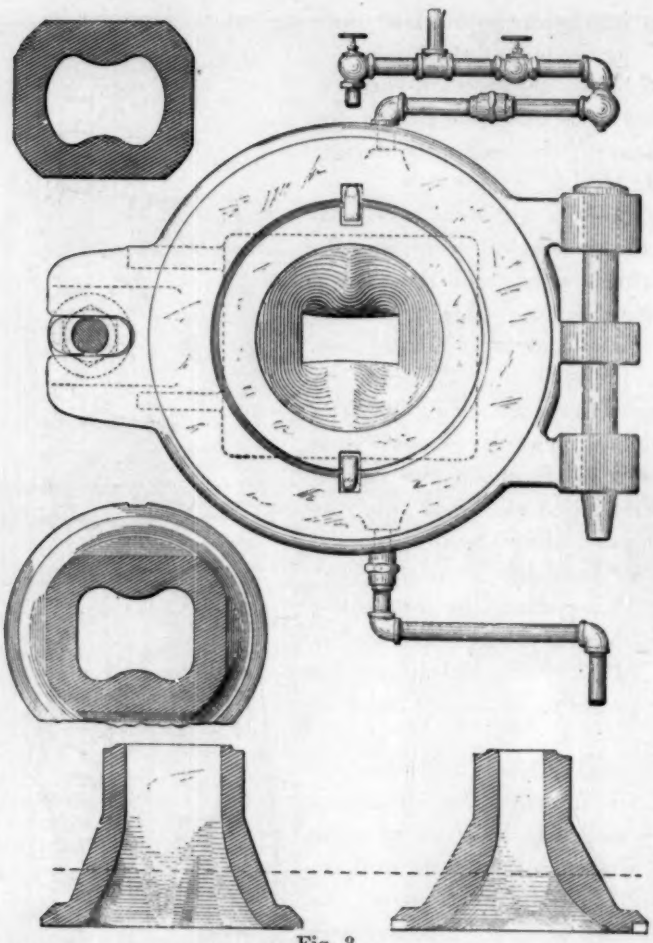

Fig. 3.

sides of the die, the projections being much larger opposite the larger diameter of the die.

For very wide and thin bricks we should omit the resisting projection wholly at the short diameter of the die, or at the edge of the bricks, but facilitate the spreading of the clay outward to the edge, rather than into the corners only.

Fig. 4 (shown on the screen) is the *sanding device*, the original of which was invented by our foreman, Wm. Mendham, and possesses the key to a valuable improvement in the art of making bricks by machinery. It has since been improved by Sanford W. Lasor and

myself, and is the subject of two patents issued and two pending. It performs the function of sanding a brick after it has been moulded, a thing never before successfully accomplished by machinery.

Fig. 5 (shown on the screen) shows side elevation of the machine arranged with the *stone extracting* rolls, clay elevator, and clay mixer and sprinkler, in combination with the brickmaking machine.

There are some clays so tenacious, that it is with great labor that they are got into shape to handle with a shovel, or to soak with water, and at the same time containing boulders of "flint," "granite," or "limestone," the latter of which is fatal to good bricks, if allowed to go into them, even if crushed to powder. At least twenty-five per cent. of the bricks made from "Chicago clay" *burst* by the slacking of the lime, burned from the limestone moulded in the brick.

The conical rolls crush the lumps of clay and reject the stones—ejecting them at the end through a spout.

Sometimes it is necessary to *reduce* the strength of the clay by introducing and mixing with it large quantities of sand and loam, or to mix different quantities of clay.

This mixing device consists of an annular pit, say ten feet in diameter, into which the different materials are dumped direct from the bank, or as in this case, elevated from the stone extracting rolls. Water is supplied from the perforated pipe, carried around and over the clay. As the clay is being sprinkled these curved mixing arms hook under the heaps of different materials, tumbling them over and over, mixing them together and gradually move the mixed and moistened mass into the hopper of the brick machine proper. This device saves the labor of one or two men, besides doing the work much better.

Fig. 6 (shown on the screen) shows a plan view of this device from which its operation can be more readily understood.

Fig. 7 (shown on the screen) shows what we term a set of compound rollers. These are for working very tenacious clays in large lumps. Rolls of small diameter will not take large lumps of hard, tenacious clays, particularly if they be wet on the surface, when they become very slippery. These large rolls run, say two inches apart, griping and crushing the clay to that thickness and rejecting the larger stones. The crushed lumps fall into the smaller conical rolls, where the clay is reduced to sheets or lumps, say half an inch in diameter, and the stones ejected through the spout, the clay falling into the brick machine through the conical hopper. The rollers are made of hard or chilled

iron in the form of shells, whereby they can be easily and cheaply renewed.

Some clays are so sticky, *like tar*, that they defile everything they touch. Such clays cannot be worked in the machines already described, from the fact that they stick with such tenacity to the cut-off blade that it tears the ends of the bricks, and clogs up the cut-off device. Such clays are usually very smooth and free from stones, gravel, or other foreign substances, and may be successfully manipulated by machinery that would be wholly impracticable in ordinary rough clays.

Fig. 8 (shown on the screen) shows what we term our "C" machine. It is composed of the "B" tempering, expressing, and sanding device, with the automatic wire cut-off. This is an entirely new device only very recently reduced to practice, and one that bids fair to fill a long-felt want. The device is clearly shown by the diagram. The device is wholly automatic, and runs without any special care or attention.

Fig. 9 (shown on the screen) shows an embodiment of the leading principles of the already described machines B and C, and is what we term our D or Village machine.

The "motive power" and "the engineer" are to be found on every farm, and the machine is *small*, *simple*, and *strong*, easily managed, and is designed to produce from eight to ten thousand bricks per day.

There are no elements in it not already shown, but a combination of those best suited for a small, inexpensive brick plant, and is designed to fill a great want, made manifest to us by the number of inquiries we have had for just such machinery.

The machines described as B or C will perform the work of one hundred men without machinery—making ordinary bricks.

The leading features of this machine are applicable to many other uses.

For instance, there is one machine running in this city, producing thirty thousand round cheese per day from cow's milk.

By compressing argilacious iron ores it is working a revolution in *smelting iron*, increasing the yield of the furnace at least ten per cent., improving the quality of the iron, and rendering *ores*, heretofore thrown away as useless, the most valuable.

Our machine is now successfully compressing fine ores from the great Cornwall mines at Lebanon, Pa.

There are on the platform a few thousand minature bricks, made by

the machine now before you, which are at your disposal. Also, some specimens of rough bricks, full size; compressed iron ore, roasted and some unroasted; and as a curiosity, some specimens of "Terra Cotta lumber," not made by our machine, but which can be. We will undertake to produce *joist, scantling, cornice,* or *square saw logs* at the rate of thirty thousand feet per ten hours.

EXPERIENTIAL PRINCIPLES OF CONTROLLED COMBUSTION.

By E. J. Mallett, Jr.

[A paper read at the Stated Meeting of the Franklin Institute, held Oct. 18, 1882.]

I shall confine the remarks which you have kindly invited me to make to a consideration of the industrial consumption of fuel when used in steam generators, and will endeavor to present a new aspect of the subject.

The chemical statics of combustion, that is, the laws governing the cause of the formation of certain resulting gases, which are the products of combustion, are too well known to be adverted to. The chemical dynamics of combustion and inflammation, that is, the intermediate causes brought into action before the final products of combustion escape, are less clearly understood.

Even at present no uniform opinion exists as to why ordinary illuminating gas, issuing from a Bunsen burner, should lose luminosity by the admixture of air with the flame. The general belief is that air, gaining access to all parts of the flame, oxidizes the carbon of the gas, thus destroying luminosity by the instantaneous combustion of the carbon.

The fact, however, that if nitrogen, carbonic acid, or other inert gas, instead of air, enters the openings of a Bunsen burner, the flame will become non-luminous, indicates that it is not oxidation that destroys luminosity.

For our purpose it is useless to advert to the present state of knowledge relative to the chemical dynamics of combustion; the vastness of the subject would tire us. I have endeavored, after thought and experiment, to arrive at some general conclusions, and to contribute towards the elevation of industrial combustion from art to science.

Possibly I should be permitted with justice to enunciate these results as experiential principles.

If fuel energy could be developed through combustion only, unattended with possible inflammation, the problem of rendering such combustion practically perfect might be readily solved. Carbon, however, when insufficiently oxidized, produces flaming carbonic oxide, and, as hydro-carbon fuel always evolves flaming gases, it is the combustion of these flaming gases that presents graver difficulties than would arise if fuel was solely carbon capable of but one combination with oxygen, namely, carbonic acid. To create a science of industrial combustion of fuel we must be able to predict with certainty what furnace devices shall be employed to reduce fuel waste to its minimum.

In searching to remedy the admitted loss of fuel, as universally burned, my method was,

1st, to review and study each cause of fuel loss;

2d, to formulate and prescribe certain principles or necessary and possible conditions essential to perfect combustion, and

3d, to construct mechanical appliances which should be subservient to the principles considered essential.

I will, therefore, this evening treat our subject in conformity with the three classifications just mentioned, and will first refer to causes of fuel waste.

Coal gas, whether generated in a retort or a furnace, is essentially the same. Again, strictly speaking, it is not inflammable; as, *by itself*, it can neither produce flame nor permit the continuance of flame in other bodies. A lighted taper introduced into a jar of carburetted hydrogen (coal gas), so far from inflaming the gas, is itself instantly extinguished. Effective combustion, for practical purposes, is, in truth, a question more as regards *the air* than the gas. Besides, we have no control over the gas, as to quantity, after having thrown the coal on the furnace, though we can exercise a control over that of the air, in all the essentials to perfect combustion. It is this which has done so much for the perfection of the *lamp*, and may be made equally available for the *furnace*.

With reference to the *mode* of introducing the air, it is not a little remarkable that many overlook, or even dispute, the difference in effect, when it is introduced through *one* or *numerous* orifices.

The body of air, by passing through a single aperture, produces the action of a strong current, and obtains a direction and velocity antag-

onistic to that lateral motion of its particles which is the very element of diffusion. In this case, passing along the flue, the stream of air pursues its own course at the lower level, while the heated products fill the *upper one*. It is here evident, according to the laws of motion, that the two forces, *acting in the same direction*, prevent the two bodies impelled by them (the air and the gas) from amalgamating.

The *appearance or non-appearance of visible smoke* is no test either for or against the admission of air, *as to quantity*. The consequences of regulating and varying the quantity of air admitted, so as to suit the varying state of the furnace, as regards the quantity of gas given off, also deserves attention. It is quite certain that, to effect the perfect combustion of all the combustible gases produced in a furnace, a large demand for air (distinct from the air entering the grate) *always exists;* also that by entirely *excluding air* smoke is produced, and the heat diminished in all states of the fire.

Chimney draught, operating through the levity of hot air, causes a fuel loss, varying with the rate of combustion, and which may amount in practice to 35 per cent. of the total heat produced.

A FIRST fuel loss arises from air entering the furnace, and absorbing a much larger amount of heat than it gives back before it passes out of the chimney.

Of the two combustible constituents of coal, the carbon and the hydrogen, the former is a solid and the latter is a gas. When coal is sufficiently heated the hydrogen escapes and the carbon, for the most part, remains behind. This is what occurs in a retort in the manufacture of illuminating gas.

The same thing occurs to a certain extent when a fresh charge of coal is thrown into a furnace. The cold fuel at first chills the fire, and after the expulsion of its moisture becomes hot enough to decompose and unite with oxygen. A most important fact must here be observed, namely, that the carbon does not burn until after the hydrogen. A fire box of a furnace thus simulates a gas retort, producing volatile hydrogen, which passes up a big gas pipe, the chimney, and is lost in space, unless we contrive to bring enough oxygen in contact with it to burn it before it enters the chimney.

A SECOND fuel loss is caused by unburnt hydrogen and hydrocarbons distilled from the coal passing up the chimney into space.

A THIRD fuel loss arises from furnace suffocation, or too little air.

A deficiency of air simply means a production of carbonic oxide and

loss of heat. It must not be assumed, however, that it is only all-sufficient to admit a full supply of air through the grate of a furnace to produce a perfect combustion of the fuel.

A FOURTH fuel loss is caused by all the necessary air entering only through the ash-pit of a furnace.

Suppose, as is always the case in a firebox, that another stratum of coal or carbon is above the first tier. The carbonic acid produced by the burning of the lower layer, in passing through the superimposed layer, unites with more carbon and becomes converted into carbonic oxide. It is evident, therefore, that when coal is burning in layers the property possessed by carbon of uniting with carbonic acid produces the same effect, in a less degree, however, as if too little air was being supplied.

If, however, this escaping carbonic oxide could meet an additional supply of oxygen above the fuel it would be burned and pass off as carbonic acid.

Although carbonic oxide will burn when mixed with air and produce heat, this can only occur at a certain temperature; if, therefore, cold air comes in contact with carbonic oxide, escaping above the fuel, it will mix with it without inflaming it, consequently,

A FIFTH fuel loss arises from the admittance of air above the fuel at a temperature below the burning point of the escaping carbonic oxide.

The supply of air to fuel must be divided into two volumes, one to maintain the combustion of the solid fuel and the other to burn not only the carbonic oxide passing off the surface of incandescent fuel, but also to ignite the gases produced from the hydrogen of the fuel.

As a fresh charge of coal cools a fire, and as cold air entering beneath a grate is also a cooling agency, it is evident that at the moment a fresh charge of coal enters a furnace the proportion of air entering beneath and above the grate should be changed. More air should enter above the fuel to burn the rapidly forming gases, and less should enter through the grate, because less is required, and a diminished supply will prevent the cooling of the fire.

A SIXTH fuel loss, therefore, arises from unvarying volumes of air entering beneath and above the fuel.

As the volume of air entering a furnace in a given time depends upon the velocity with which it travels it is evident that

A SEVENTH fuel loss is caused by the existing adequate means of

regulating the amount of air entering a furnace, owing to its variable velocity.

It is therefore necessary to know the rate of a current of air when entering a furnace before we can decide on the necessary area for its admission. As the furnaces in use operate with open ash-pit, an attempt is made to make the grate-bars answer for dampers. That is, so many square inches of area of aperture between the grate-bars is allowed for so many square feet of grate surface.

If, for example, six square inches of opening is allowed for each square foot of grate surface, with air moving at six feet a second, the same amount of air moving at forty feet a second would enter one square inch of opening. Therefore, without knowing the velocity of the air, no regulation of air can be made by the grate openings. In practice, the importance of knowing how much air enters between grates is entirely ignored.

The velocity of air entering a furnace by chimney draft varies with the heat of the fire, therefore when a fresh and cold charge of fuel is thrown into a furnace the draft diminishes at the exact time when more air is required to burn gases and prevent smoke.

An EIGHTH fuel loss arises from the admission of air to furnaces in bulky instead of divided currents.

It is obvious that air entering the ash-pit becomes thoroughly subdivided in passing upwards through the grates, but this does not obtain with air introduced above the fuel, unless special provision is made.

The necessity of having hot air in fine currents to complete the combustion of fuel gases indicates the serious objection of permitting air to enter through the furnace door opening, or even through the door itself. If we carefully consider that for the combustion of fuel gases the desideratum is to have the necessary oxygen at the right place at the right moment, it is evident that any air entering beneath the bars or through the door is necessarily a little in arrear of the gases to be burned in the combustion chamber of a furnace.

Although the entering air may move with the same velocity as the unconsumed gases, it *connot catch up with them*, because the start is uneven.

A NINTH fuel loss consequently arises from the admission of air for the combustion of fuel gases at any point except just where it was wanted at the moment, namely, in the hottest part of the combustion chamber.

A TENTH cause of fuel loss is the cooling effect of heat-absorbing surfaces in proximity to the burning fuel, and the sequel to this is

An ELEVENTH cause of fuel loss, arising from lack of capacity of the combustion chamber to burn fuel gases before they are forced through a steam boiler.

The dilution of oxygen by nitrogen in our air is very nicely suited to industrial combustion; if, by further dilution, the amount of oxygen in a cubic foot of air becomes decreased, the rate of combustion diminishes. After a certain dilution, combustion cannot be maintained at all. It follows, therefore, that every additional volume of steam or other non-supporter of combustion which gains access to the combustion chamber of a furnace interferes with combustion. Therefore

A TWELFTH fuel loss arises from steam, in addition to the air necessary for combustion, gaining acccess to the combustion chamber of furnaces.

A THIRTEENTH fuel loss arises from the escape of carbonic oxide and smoke.

When smoke is once produced in a furnace it is as impossible to burn it or convert it to heating purposes as it would be to convert the smoke issuing from the flame of a candle to the purposes of steam and light.

The presence of smoke being noticeable no test other than the eye is required. Carbonic oxide, however, is invisible and inodorous, and must be sought for by other means.

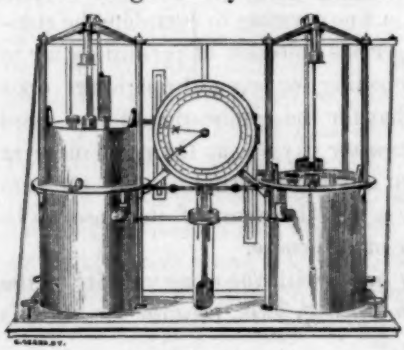

Fig. 1.

Again, the presence of free oxygen in the gases of combustion indicates that more air than necessary is being supplied to the furnace. In order to readily detect the presence or absence of these gases in furnace products I constructed an apparatus called a differential furnace gas meter which records on a dial the per cent. in volume of any gas existing in escaping flue products.

Fig. 1 represents two gas-holder tanks, in which two cylinders of equal capacity are counterpoised. Geared to each cylinder is a separate index-needle, which is caused to revolve around the dial by the

upward or downward motion of the cylinder. Between the cylinders is a glass receptacle in which any gas-absorbing material can be placed. When it is desired to test furnace gases a small pipe introduced into the furnace flue permits the gases of combustion to enter one of the cylinders by aspiration, when the cylinder is caused to ascend. Now, while the cylinder is at its greatest height, the corresponding cylinder rests within the tank entirely filled with water. If, now, the first cylinder is caused to descend by being weighted and the induction pipe is closed, while the pipe leading to the intermediate glass vessel is opened—the gases contained in the first cylinder being expelled, pass through the absorber into the second cylinder, which in turn begins to rise.

As both cylinders are of exactly the same capacity, the one descends proportionately as the other ascends. If, however, any of the gases passing through the absorber are taken up, it is evident that the ascending cylinder will not rise as rapidly as the first cylinder descends. As each index needle is geared independently to each cylinder, any difference of motion in the cylinders is registered on the dial; and the divergence between the two needles, when the descending cylinder has reached the bottom of the tank, indicates the per cent. of gas which has been absorbed, and, consequently, the amount present in the gases is thus analyzed. This apparatus diminishes the risk of error to the minimum, owing to the large capacity of the cylinders, each holding eight hundred cubic inches. The apparatus was invented for the purpose of verifying the results which were anticipated would be produced by the system of "Controlled Combustion."

The "Experiential Principles," which may be reduced to twelve, naturally do not embrace all the necessary conditions of combustion.

I. Hydrocarbon fuel tends to burn with less carbonic oxide and smoke, proportionately as its environing atmosphere diminishes in tension.

II. Hydrocarbon fuel tends to evolve carbonic oxide and smoke, if burned in a furnace, until the temperature of the fuel reaches a certain elevation.

III. The tension of fuel gases within a furnace is never less than that produced by the burning of the fuel itself by natural draft, and is never sufficiently low, when compared with the rate of combustion, to prevent the origination of smoke.

IV. What was considered probable by Rankine, Peclet and others

is demonstrated in "Controlled Combustion," namely, that air for dilution in furnace combustion would be rendered unnecessary, providing chimney draft could be dispensed with, and providing also that without such draft a supply of sufficiently heated air, in divided currents, could enter the combustion chamber in regulable quantities.

V. To maintain an atmosphere of the desired tension within a fire-box, an air exhauster must supplant the chimney, and the influx of air into the ash pit must be throttled.

VI. When combustion is urged by a blast fan, causing furnace air tension to be greater than normal barometric pressure, both physical and chemical actions result, differing from those created by a draft or flue fan, incompatible with perfect combustion.

VII. Hydrocarbon fuel, freshly charged into a furnace, must not be supplied with air to initiate its burning until the temperature of the fuel is sufficiently elevated; *i. e.*, the fuel must begin to distil before it begins to burn.

VIII. To compel a rapid and intimate mixture of hot air with combustible fuel gases, generated within a boiler fire box, these gases must not be allowed to ascend or envelope the boiler until after they enter the combustion chamber through channels in close proximity to those conducting fresh heated air into the combustion chamber.

IX. The heat from escaping furnace gases, after leaving a steam boiler, is more completely radiated for additional heating and boiling of water, if such gases are rendered athermous by being kept at their dew point.

X. It is possible, in practice, to superheat all the feed water required by a steam generator, from the waste heat of escaping gases, to a temperature equal to that of the water within the generator, and also to supply a portion of the feed in the form of steam.

XI. The potential power of a steam generator may be increased to a hitherto greater limit without diminishing the economic result

XII. To burn fuel rapidly, without creating a too high localized temperature, it should not be supplied with sufficient air to burn it at once to carbonic acid only, but considerable carbonic oxide should be produced, to be afterwards burned in the combustion chamber.

The application of these experiential principles in "Controlled Combustion" is effected by the following mechanical devices. With reference to the First Principle, it is known that as air becomes compressed it more nearly approaches the solid condition, and as its

tension is decreased, so in direct proportion is its molecular mobility increased. An alcohol flame, which burns almost invisibly, is rendered quite luminous if burned in an atmosphere much above normal barometric pressure, and by a continual compression of the air the flame becomes smoky. Conversely, a candle flame burns almost invisibly at great altitudes. When by air compression its molecular mobility is increased, it penetrates a flame less rapidly than air of less tension. Smoke and carbonic oxide tend to originate whenever the atmosphere in which a hydrocarbon fuel is burning is not sufficiently mobile to rapidly penetrate flame and oxidize the carbon before it escapes. Part of the equipment required with "Controlled Combustion" consists of a register which can completely close the openings in the door of the ash pit, as represented in Fig. 2. When bituminous coal is first thrown into the furnace the temperature of the fuel must become elevated before the fuel is permitted to burn, as set forth in Principle VII. To this end the lever shown in Fig. 5, and actuating the ash pit opening, is caused to completely close it. Now, as the flue fan (see same Fig.) is at all times exhausting the furnace gases, and as no air can enter the ash pit, the fresh fuel cannot burn, but merely begins to distil as it would in a gas retort. After the temperature of the fuel is sufficiently high its burning is allowed to begin by the admittance of air through the ash pit. As, however, the air gaining access to the fire box through the ash pit is throttled, the atmosphere within the fire box is kept at a lower tension than is possible with chimney draft. By this means the coal burns without originating carbonic oxide and smoke, and the demands of Principles I, II and VII are responded to.

The "Experiential Principles" formulate, as it is believed, absolute conditions demanded for a perfect combustion of fuel and a greater utilization of the heat of escaping gases, and, as practice fully sustains the ideas advanced, force is given to the following statement, namely:

That it is impossible to burn by hydrocarbons, either in a furnace, a lamp or gas burner, without the production of carbonic oxide and smoke, unless more air environs and dilutes them than is theoretically required for their combustion, and that proportionately as the density of the environing atmosphere decreases, within limits, so will the amount of air required to burn fuel without smoke diminish and approach nearer to the amount theoretically required for a perfect combustion. If it were possible by any device to only mix the theoreti-

cal amount of hot air with sufficient rapidity and intimacy with fuel in a furnace, it is obvious that no carbon could escape oxidation; as, however, this is as yet practically unattainable, we must either use a surplus amount of air required theoretically, and thereby produce waste, or endow air with greater molecular mobility by reducing its density, and thus favor its mixing capacity.

With reference to Principle III, it should be appreciated that the tension of furnace gases depends upon the rate at which the fuel is burned.

It therefore follows that the tension is limited and uncontrollable. If we attempt to prevent carbonic oxide and smoke by lessening the air tension, then we must increase the rate of combustion. What is required, however, is to lessen the tension in a greater ratio than is possible by increasing the rate of combustion. It is obvious that natural or chimney draft, *i. e.*, draft produced by the fuel itself, depending as it does upon the rate of combustion, can only be increased at a fixed ratio.

To enforce the requirements of Principles IV and V, chimney draft is entirely dispensed with in "Controlled Combustion," being replaced by mechanical draft. A suction fan, as represented in Fig. 2, is employed, requiring a power to actuate it amounting to about three per cent. of the total fuel power.

Although various methods have been adopted to introduce hot air in subdivided currents into a combustion chamber, experience has shown that such air never really reached a sufficiently high temperature. In the present system tubular grate bars are employed, open at both ends. The boiler front is perforated, as shown in Fig. 2, such perforations being coincident with the front opening of the grate bars. The rear end of the bars passes through an iron box within the bridge wall, or rather septum wall, as shown in the furnace, Fig. 3.

As the air openings to the ash pit can be throttled, the air necessary for the combustion of the fuel gases can be compelled to pass through the tubular grate bars, and thus enter the combustion chamber in divided currents of a high temperature.

As it is necessary to regulate the air entering the ash pit simultaneously with that passing through the grate bars, the lever is made by one motion to actuate the air resisters of the grate bars, and also the ash pit door registers.

With reference to Principle V, it may be stated that although an

air exhauster diminishes the tension of fuel gases in the fire box, still, if the influx of air through the ash pit is not properly regulated, a sufficiently low air tension will not result.

With respect to Principle VI, it should be noted that if air is supplied to a furnace by a blast fan it is obvious that the air pressure within the fire box is greater instead of less than normal barometric pressure. The physical result of forced air is to cause the flame from the fuel to tend to rise at right angles to a grate surface, and to impinge directly upon that part of the boiler situated directly over the fire box. The chemical result of hydrocarbon fuel, burning in an atmosphere of greater or less tension than the normal, has already been adverted to.

There are two causes that produce the liberation of carbon from fuel in an unoxidized condition, *i. e.*, as smoke, namely, a low temperature of the fuel, and an insufficiently low air tension within the fire box. To respond to the demands of Principle VII, a fresh charge of bituminous coal is not allowed to burn when first thrown into the fire box. At this time the lever is caused to close the air openings of the ash pit. The fresh fuel, from the heat derived from the already incandescent fuel, begins to distil, and the chemical actions resulting in a gas retort are simulated. The draft fan, inducing powerful currents of air to enter the combustion chamber through the hollow bars, permits the fuel gases distilled from the fuel to be burned. After a certain lapse of time, depending on the grade of fuel, the ash pit air registers are opened, whereby a real burning of the fuel begins.

Principle VIII indicates that although every possible provision may be made for the admittance of hot air, in divided currents, into the combustion chamber of a furnace, an imperfect admixture of the air results unless special provision is made to prevent the unconsumed gases from rising upwards, and thus get cooled before they come in contact with the air necessary for their combustion.

To this end the furnace in the present system is divided by a septum wall into the fire box proper and the combustion chamber, as shown in the sectional views, Figs. 3 and 4.

As the openings of the septum wall, through which flame and unignited fuel gases pass, are only slightly above the rear openings of the hollow grate bars through which fresh hot air is flowing, a rapid and intimate mixture of gases and air results.

We are indebted to the interesting experiments of Professor Tyn-

dall (see "Heat as a Mode of Motion"), which show how air entirely freed of moisture permits radiant heat to pass through it without absorbing any of such heat; and, conversely, how air saturatud with moisture is a rapid absorbent of radiant heat. Tyndall also shows that in proportion as the radiant heat absorbing power of moist air increases is its power to radiate its own heat increased. It should be remembered, also, that moist air conducts and convects heat with infinitely greater facility than dry air.

Now, as fuel gases obey the same law, it is obvious that in order to compel them to radiate, conduct and convect their heat with the utmost rapidity they should be saturated with moisture and be maintained at their dew point. Air rendered by moisture opaque to radiant heat is in an "athermous" condition. As fuel gases, after having imparted say seventy per cent. of their heat to a steam boiler cannot liberate the balance with equal facility, owing to their reduced temperature, the process of moistening such gases is resorted to in "Controlled Combustion."

In practice, such escaping fuel gases, before they are drawn through the fan to be delivered into space, pass through what is termed an "Athermous Superheater."

This appliance, represented in Fig. 2, consists of an air-tight case, containing iron pipe of any desired amount. The gases, just previous to entering the superheater, are moistened to saturation by the water spray shown in the same figure. The exhaust steam from the engine that actuates the fan, together with the water spray, maintains the air at its dew point, which is evidenced by the constant dropping of water from the pipe seen to project from the side of the superheater near its base.

The effect of this is to cause the escaping gases to be cooled down to a lower temperature than has been hitherto possible. The amount of water supplied by this spray is quite an insignificant quantity.

The superheater effectually fulfills the requirements of Principles X and XI. It is most desirable to heat feed water to as high a temperature as possible, each 100° Fahr. being equivalent to about ten per cent. saving of fuel. The "Athermous Superheater" receives the cold water supply from a pump at the base of the packed tubes. The water here enters a manifold, and distributes itself through the layers of pipe, passing in an upward course. The moistened heated gases enter the superheater at the top, and pass between the piping which

is at right angles to the current of gases, and then enter the exhaust fan.

The upper manifold of the superheater connects with what is termed a "Separator," which consists of a steam-tight cylinder, into which the superheated water separates into steam, which enters the steam space of the boiler, and boiling water, which is forced into the feed water pipe of the boiler. The "Separator" is seen in Fig. 2, placed between the superheater and the boiler. As the superheater is, in fact, an auxiliary steam generator, it is provided with a steam gauge, the pressure of which is always slightly above that of the steam boiler itself. The feed water, before entering the boiler, becomes heated to the same temperature as the water within the boiler, and, as a part of the feed enters the boiler as steam, a great saving of fuel is realized.

The facility with which furnace gases at their dew point are made to part with their heat permits of a rapid rate of combustion without a corresponding loss. It is thus that what is said in Principle XI, relative to the potential power of boilers, becomes realized.

The question of localized temperature is an important one when fuel is being rapidly burned under a steam generator. Principle XII indicates that the fuel should in part be burned in stages. If more than twelve pounds of air to the the pound of fuel enters a furnace, the temperature will be less than with just the theoretical amount; and if less air than is required for the perfect transformation of the fuel into carbonic acid enters the furnace, this will also produce a lower temperature of combustion. What is required, therefore, is to supply fuel with as nearly twelve pounds of air as possible, and to divide the weight of air between the fuel and the fuel gases, so that while, for example, eight pounds of air is supplied through the ash pit, the remaining four pounds will enter the combustion chamber. Thus the fuel does not receive enough air to entirely burn it to carbonic acid, whereby a too intense localized temperature would result, but a supply so gauged as to produce considerable carbonic oxide, to be afterwards consumed by the air entering the combustion chamber. In the present practice under consideration this is what is undertaken. The air registers in the ash pit throttle the supply from that quarter, and the hollow bars admit air into the combustion chamber to make up for the deficiency.

The saving of fuel in "Controlled Combustion" originates from three distinct sources:

1st. A practically perfect combustion.

2d. A utilization of heat from furnace gases hitherto allowed to escape.

3d. A use of cheap fuel, such as anthracite, buckwheat or dust, or bituminous dust, permissible by the increased draft.

The equipment for the system of "Controlled Combustion" can be applied to the existing forms of locomotive, marine, and stationary boilers. Fig. 5 illustrates the exterior of a locomotive. It will be noticed that the smoke funnel is dispensed with. The invisible products of combustion escape through an opening on the periphery of the extended boiler casing, not shown in the engraving. The exhaust nozzles are not used, the draft being produced by the exhaust fan, shown within the boiler casing in Fig. 4. By this plan a powerful draft can be produced, even when the locomotive is at rest, by the small engine which actuates the fan. The engines of the locomotive are relieved from the back pressure caused by exhausting steam through the nozzles, and the resonant noise is avoided. The exhaust steam is delivered through the pipe seen along the side of the locomotive, from whence it passes into the exhausting compartments of of the tender, to be described.

Fig. 4 represents the interior view of the boiler, where the fire box is seen to be separated from the combustion chamber by a fire-brick division or septum, as already alluded to.

The tender is divided into three compartments. The upper one is the receptacle for the fresh water; the middle one contains copper tubes, communicating with the external air in front, and with a suction fan in the rear. The exhaust steam circulates around the upper tubes, and becomes in part condensed, the resulting hot water falling into the lower compartments. The uncondensed steam then comes in contact with a spray of water falling from the upper compartment, and the condensed water also enters the lower compartment, from whence hot water is pumped into the boiler.

The air used to condense the steam is employed for HEATING AND VENTILATING CARS, being delivered through a conduit, which, with coupled ends, passes beneath the cars. Three registers in the floor of the car admit the heated air. This system does away with coal stoves or heaters, and supplies the car with fresh air and warm air.

Figs. 2 and 3 represent the equipment for stationary boilers, already described. The lever is seen to actuate both the ash pit, air registers

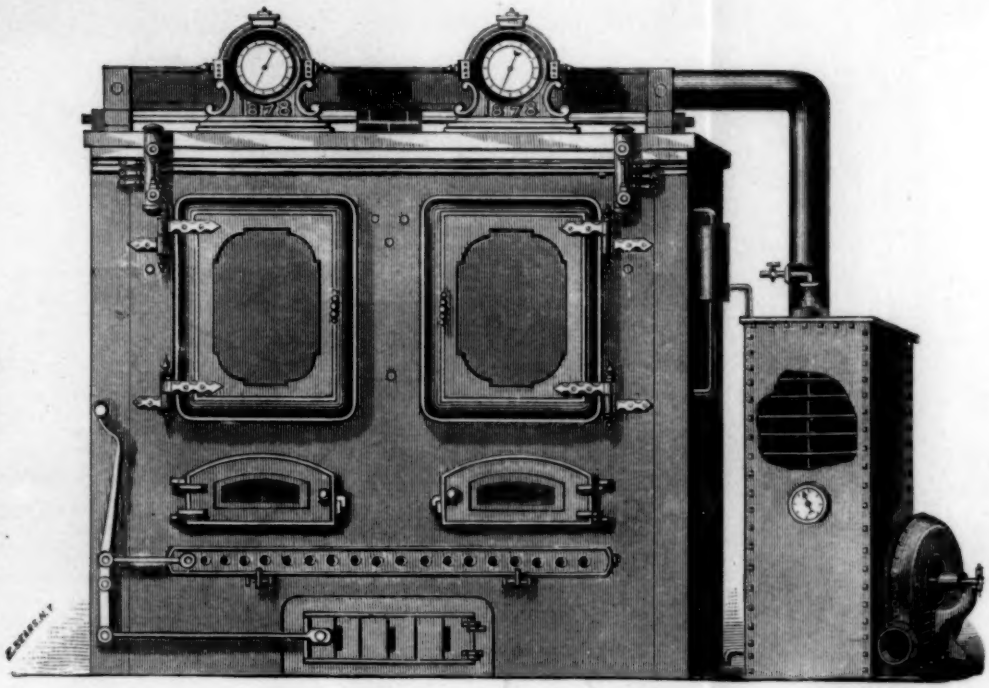

Fig. 2.

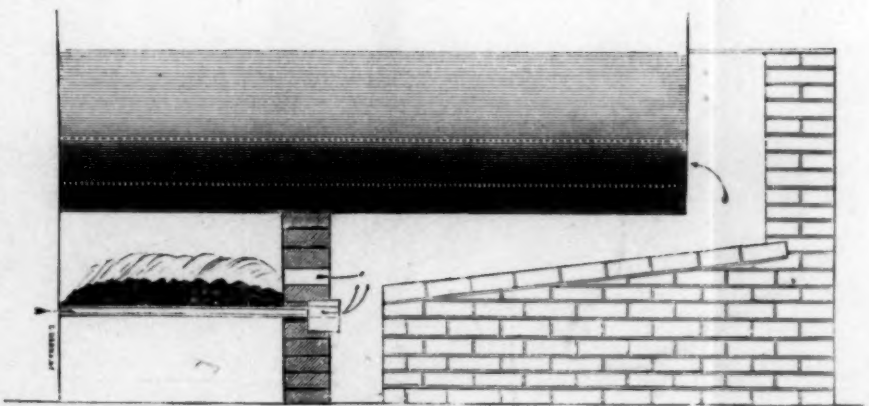

Fig. 3.

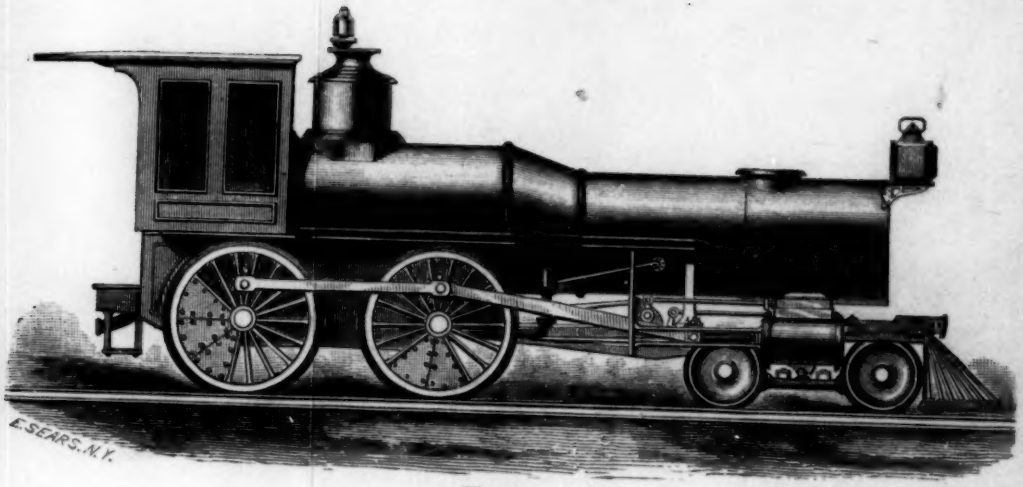

Fig. 4.

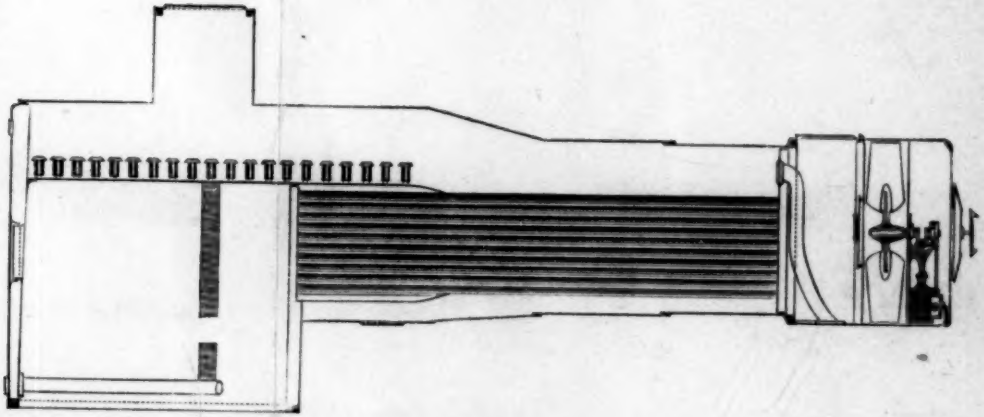

Fig. 5.

and those controlling the air passages through the tubular bars. The Athermous Superheater, seen on the right of the boiler, superheats the feed water, and then, by means of a Separator, seen between the superheater and the boiler, together with some steam, passes into the steam space and water space of the boiler. The exhaust fan can be operated either by a small engine or by one already in operation. A small amount of boiling water taken from the feed pipe is caused to constantly moisten the hot gases which enter the superheater, and thus maintains them at their dew point, so as to facilitate the radiation of their heat to the stacked pipes. The superheater, being in effect an auxiliary steam boiler, is supplied with a steam gauge, the pressure on which is always slightly greater than that of the boiler.

OLSEN'S TESTING MACHINES.

From the Report of the Secretary, November 15, 1882.

UNIVERSAL TESTING MACHINE.—The illustration (Fig. 1) represents a testing machine of 50,000 pounds capacity, combining certain novel and useful features, introduced for the purpose of subjecting materials used in construction to every variety of strain. The machine was designed and constructed by Mr. Tinius Olsen of Philadelphia, a member of the Institute, for the Renssalaer Polytechnic Institute of Troy, and was made especially with the object of universal service, for scientific investigation and instruction. It is adapted for making tensile, crushing, transverse, and torsional tests.

The strain is applied with screws and gearing, and is operated by a crank shown in front of the cut. It is also provided with quick return motion. To bring this into play the large crank and small pinion is removed, and the larger intermediate gear-wheel turned by a handle on the same.

For convenience, and with the object of enabling the machine to be easily operated by the experimenter without help, an arrangement is added for operating the gears and screws by foot. This arrangement is represented in the illustration by the long lever crossing the lower gear-wheel of the machine.

The strain to which the specimen of material operated upon is subjected will bear upon the platform of the machine, which is supportod on a system of scale levers, and the amount of the strain balanced

and indicated on the beam, in the main similar to the arrangement of a platform scale.

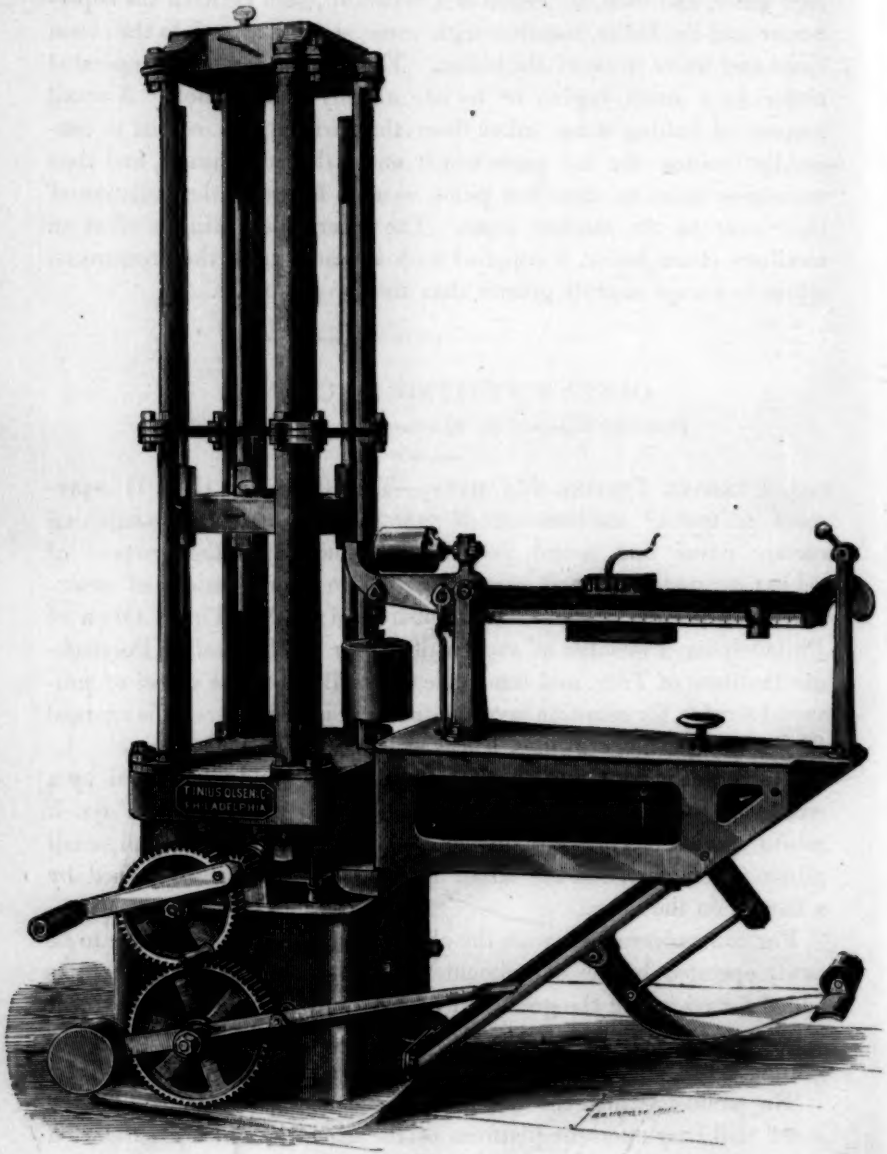

Fig. 1.

As the machine is represented in the cut, it is arranged for testing long specimens in tension up to 5 feet lengths. For ordinary short specimens of 2 feet lengths and less the top part can be removed, thus making it more convenient to place and replace specimens, as a man can then reach both ends of the specimen when standing on the floor alongside the machine.

As a new, and for scientific investigation important feature, this machine is provided with an arrangement for applying intermittent strains, whereby a specimen under a certain strain may be instantly subjected to a certain increased strain and again as suddenly released. When an ordinary test is made the foot lever to the right of the machine is in position when up under the frame of the machine. The intermittent strain is applied by depressing this lever, and the amount of this extra strain is measured on the weighing beam, and set or limited to the desired amount by the screw and hand-wheel, shown under the weigh beam.

With this machine, then, the experimenter is enabled to apply a very gradual and quietly increasing strain, which can be obtained by the use of screws and the crank motion; also, when desired, a sudden and intermittent loading or series of strains of any desired duration.

In the size of machine illustrated (of 50,000 lbs. capacity) the intermittent strains can be regulated to any desired amount up to 30,000 lbs. by the exertions of one man, the maximum amount depending upon the rigidity of the material experimented with. Machines of this kind have been built up to 200,000 pounds capacity.

Horizontal Chain Testing Machine.—Fig. 2 represents a horizontal chain testing machine (built for the Iron City Chain Works, Pittsburgh, Pa.), capable of stretching out and testing 15 fathom length of chain, and consists of a straining device and a recording device, both arranged at the same end of the machine so that all the working parts are under the eye of the operator.

The straining device in this case consists of hydraulic cylinder, power pumps and a device for changing and stopping the motion of the piston in the cylinder without stopping the pumps as well as an automatic stopping arrangement at each end of the stroke of the piston.

The recording device consists of scale levers and a beam with sliding poises.

The hydraulic cylinder presses against the main levers, and this again transfers the strain to the equal beam, which alters the horizontal stress

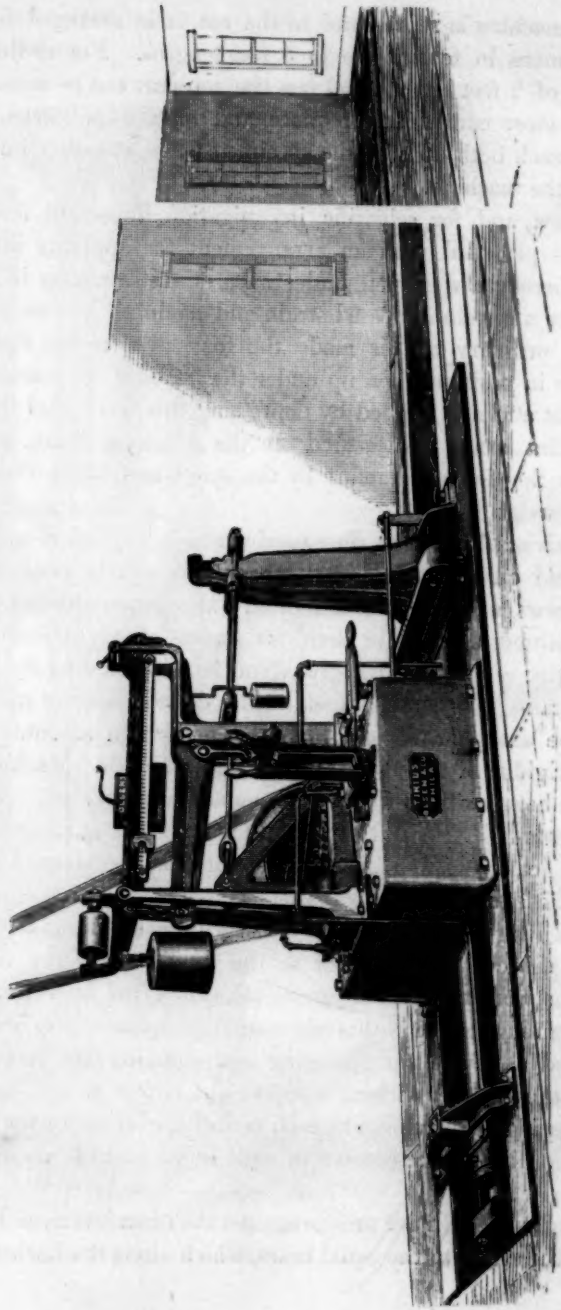

Fig. 2.

to a vertical one, and is further transmitted through the intermittent lever to the beam where it is balanced and recorded.

One of the features secured in this arrangement for horizontal machines is that the machine can be sealed with standard weights and sealing levers the same as is done in sealing a platform scale, or one of the vertical machines.

THE SPECTROSCOPE AND THE WEATHER.

By C. Piazzi Smyth,
Astronomer Royal for Scotland.

What may be done with the spectroscope in the matter of weather is, for the present at least, confined almost entirely to the question of rain—as, Will it rain, or will it not; and, if it will, heavily or lightly? The manner in which the spectroscope accomplishes this useful part is by its capacity for showing whether there is more or less than the usual quantity of watery vapor permeating the otherwise dry gases in the upper parts of the atmosphere, this watery vapor not being by any means the visible clouds themselves, but the invisible water-gas out of which they have to be formed, and by means of which, when over-abundant, they obtain their privilege for enacting rain-fall. So that never were wiser words uttered and more terse philosophy than those which are to be found in the ancient book of Job, wherein, of the wondrously "balanced clouds" high up in mid-air, it is said, "They pour down the rain according to the vapor thereof."

More or less of this water-vapor is always in the air, even on the very clearest days, and a happy thing for men that it is so; for, as Dr. Tyndall and others have well shown, it moderates the excesses of hot solar radiation by day and cold radiation of the sky at night, and is more abundant in the hotter than in the colder parts of the earth. Wherefore, according largely to its temperature for the time being, the air—otherwise consisting almost entirely of nitrogen and oxygen—can sustain, and does assimilate, as it were, a specified amount of this watery vapor, invisibly to the naked eye, the microscope, or the telescope; but not so to the instrument of recent times, the spectroscope. And if the air vertically above any one place becomes presently charged with more than its usual dose of such transparent watery

vapor (as it easily may, by various modes and processes of nature), the spectroscope shows that fact immediately, even while the sky is still blue; clouds soon after form, or thicken if already formed, and rain presently begins to descend.

But how does the spectroscope show to the eye what is declared to be invisible in all ordinary optical instruments? It is partly by its power of discriminating the differently colored rays of which white light is made up, and partly by the quality impressed on the molecules of water at their primeval creation, but only recently discovered, of stopping out certain of those rays so discriminated and placed in a rainbow-colored order by the prism and slit of the spectroscope, but transmitting others freely. Hence it is, that on looking at the light of the sky through any properly adjusted spectroscope, we see, besides the Newtonian series of colors from red to violet, and besides all the thin, dark Fraunhofer, or solar originated lines, of which it is not my object now to speak, we see, I say, in one very definite part—viz., between the orange and yellow of that row of colors, or "spectrum," as it is called—a dark, hazy band stretching across it. That is the chief band of watery vapor; and to see it very dark, even black, do not look at a dark part of the sky or at black clouds therein, but look, rather, where the sky is brightest, fullest of light to the naked eye, and where you can see through the greatest length of such well-illumined air, at a low, rather than high, angle of altitude, and either in warm weather, or, above all, just before a heavy rain-fall, when there is and must be an extra supply of watery vapor in the atmosphere. Any extreme darkness, therefore, seen in that water-vapor band beyond what is usual for the season of the year and the latitude of the place is an indication of rain-material accumulating abnormally; while on the other hand, any notable deficiency in the darkness of it, other circumstances being the same, gives probability of dry weather, or absence of rain for very want of material to make it; and the band has, therefore, been called, shortly, "the rain-band." Thus, also, "rain-band spectroscopes" have been specially constructed by several most expert opticians in size so small as to be carriable in the waistcoat-pocket, but so powerful and true that a glance of two seconds' duration through one of them suffices to tell an experienced observer the general condition of the whole atmosphere. Especially, too, of the upper parts of it, where any changes—as they take place there almost invariably earlier than below—enable such an observer to favor

his friends around him with a prevision of what they are likely soon to experience.

As an example of what may be done, and done easily, after a certain amount of experience and understanding of the subject has been acquired, I append, from a lady's meteorological journal, her notes of the mean temperature of the air and the intensity of the-rain band for each of the first fifteen days of the present month, and in a final column have entered the amount of rain-fall measured at the Royal Observatory, Edinburgh, on each of those days. The darker the rain-band the larger is the figure set down for it, and it will be seen pretty plainly, on running the eye down that column and the next one, that with an intensity of either 0 or 1 no rain follows, or, we might almost say, can follow; but with an intensity of 2 rain-fall begins, and with 3 it may be very heavy. All these rain-band notes have been made with a spectroscope no larger than one's little finger, purchased some six years ago, and taken on many voyages and travels since then:

Date, September, 1882.	Mean temperature of the air.	Rain-band intensity.	Depth of rain measured in gauge at Royal Observatory, Edinburgh.
	Deg. Fahr.		Inch.
Friday, 1,	57·1	3	·044
Saturday, 2,	59·2	2	·353
Sunday, 3,	58·6	2	·015
Monday, 4,	54·4	0	0
Tuesday, 5,	55·7	1	0
Wednesday, 6,	55·2	0	0
Thursday, 7,	53·8	1	0
Friday, 8,	59·4	0	0
Saturday, 9,	54·0	1	0
Sunday, 10,	57·0	1	0
Monday, 11,	52·2	1	·040
Tuesday, 12,	48·6	0	0
Wednesday, 13,	52·8	1	0
Thursday, 14,	49·5	3	·62
Friday, 15,	56·2	2	·570

But, if so much can be done by so small a spectroscope, the question may be well asked whether more still might not be accomplished with a bigger and more powerful one, especially seeing that the dispersive powers of both chemical and astronomical spectroscopes have in late years been increased to a most astonishing extent. The ques-

tion is important, and somewhat new as well. I propose, therefore, to devote the remainder of my space to its answer, rather than to the practical rules for using the smaller instruments, especially, too, as they have been already introduced to the public, both by my friend Mr. Rand Capron, in his pamphlet "A plea for the Rain-band," and by myself, in the fourteenth volume of the "Edinburgh Astronomical Observations"; also in the "Journal of the Scottish Meteorological Society," and in the September number of the "Astronomical Register for 1877."

The greater part of higher power spectroscopes are not suitable to rain-band work, for their fields are usually too dark. But having recently built up for myself a large-sized variety of the instrument, possessing perhaps the greatest combination of power with transparency yet attained, and having it always mounted in an upper chamber looking out at an altitude of about 5° over the northwestern horizon (or most suitably for rain-band work), I will try to describe shortly its action therein.

The classical "rain-band," which in the little instrument is merely a very narrow fringe to an almost infinitely thin black line, is so magnified laterally in the larger instrument as to fill the whole breadth of the field. The thin black line before spoken of is now not only split into two, but these are both strong, thick, sharply defined lines, separated from each other by six or seven times the breadth of either. These are the celebrated solar D-lines, D1 and D2, arising from the sodium metalloid burning or incandescent in the sun. They are, therefore, perfectly uninfluenced by changes of the terrestrial atmosphere, hot or cold, wet or dry, and are, therefore, invaluable as references for degrees of visibility of the water-vapor lines and bands which rise or fall in intensity precisely with those changes. There are several of these earthly water-vapor lines and bands in and between and about the D-lines themselves; then a long breadth of band toward the red side of D1; then a pair of lines not so widely apart as the D-lines, but sometimes just as sharp and black; then two or three fainter bands; then a grand triple, of which the nearer line sometimes attains greater blackness than either D-line; then beyond that three distinct, equal-spaced, isolated bands; and, farther away toward the red, a stretch of faint haze and haze-bands.

All these go to make up the one thin rain-band of the little spectroscopes; and I fortunately had, through the month of August and

the early days of September, occupied myself each morning in noting the greater or less intensity of each and all these water-vapor lines and bands in terms of the two solar constants D1 and D2; and every such morning there was an abundance of details to see, to recognize, and to measure. But on the morning of Monday, September 4th, when the little instrument had truly enough marked 0 on its very small scale, I almost started at finding in the large instrument every member of its long rain-band group, unless it were a vanishing trace of one or two of the strongest, utterly gone; while the two D-lines were in their accustomed strength, but far greater clearness, for now they were all alone in the field save the ultra-thin solar nickel line between them and one or two others, equally thin and solar on their blue side. The stages of perceptible shade of water-vapor lines which had thus been swept away, between their this day's invisibility, and their tremendous strength no longer before than the previous Friday, might have been expressed by a scale not divided into three parts only, but into thirty; and implied such a very unusual amount of absence of water-vapor that I not only felt sure of no rain falling either next day, or perhaps for several days after, but that the weather must also be coming on colder as well. Therefore it was that I took the step of instantly writing as I did to a local paper, promising the perplexed farmers dry weather at last, though probably sharp and cold, to get in their crops.

And how was that expectation fulfilled? Various meteorologists in different parts of the country have already declared themselves well satisfied with it. But I would now beg further attention to the little daily register already quoted, showing that from and including that day, Monday, September 4th, up to and including the next Saturday, not a drop of rain fell at the observatory. Between the following Sunday and Monday, a drizzle, but only amounting to 0.04 inch, occurred, and after that there were three more days equally dry with the preceding ones. But on Thursday, the 14th, the rain-band re-appeared in both spectroscopes in all its force; rain began to fall the same day, and next day's measure at the observatory amounted to more than half an inch. Wherefore it is to be hoped that the farmers had busied themselves effectively while the dry weather lasted, for the return of these spectral lines of watery vapor showed that their autumn opportunity was then gone by.—*London Times.*

SCIENCE IN RELATION TO THE ARTS.*

By C. William Siemens, F. R. S.

Since the days of the first meeting of the Association in York, in 1831, great changes have taken place in the means at our disposal for exchanging views, either personally or through the medium of type. The creation of the railway system has enabled congenial minds to attend frequent meetings of those special societies which have sprung into existence since the foundation of the British Association, amongst which I need only name here the Physical, Geographical, Meteorological, Anthropological and Linnean, cultivating abstract science, and the Institution of Mechanical Engineers, the Institution of Naval Architects, the Iron and Steel Institute, the Society of Telegraph Engineers and Electricians, the Gas Institute, the Sanitary Institute and the Society of Chemical Industry, representing applied science. These meet at frequent intervals in London, whilst others, having similar objects in view, hold their meetings at the University towns, and at other centres of intelligence and industry throughout the country, giving evidence of great mental activity, and producing some of those very results which the founders of the British Association wished to see realized. If we consider further the extraordinary development of scientific journalism which has taken place, it cannot surprise us when we meet with expressions of opinion to the effect that the British Association has fulfilled its mission, and should now yield its place to those special societies it has served to call into existence. On the other hand, it may be urged that the brilliant success of last year's anniversary meeting, enhanced by the comprehensive address delivered on that occasion by my distinguished predecessor in office, Sir John Lubbock, has proved, at least, that the British Association is not dead in the affections of its members, and it behoves us at this, the first ordinary gathering in the second half century, to consider what are the strong points to rely upon for the continuance of a career of success and usefulness.

If the facilities brought home to our doors, of acquiring scientific

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information, have increased, the necessities for scentific inquiry have increased in a greater ratio. The time was when science was cultivated only by the few, who looked upon its application to the arts and manufactures as almost beneath their consideration; this they were content to leave in the hands of others, who, with only commercial aims in view, did not aspire to further the objects of science for its own sake, but thought only of benefitting by its teachings. Progress could not be rapid under this condition of things, because the man of pure science rarely pursued his inquiry beyond the mere enunciation of a physical or chemical principle, whilst the simple practitioner was at a loss how to harmonize the new knowledge with the stock of information which formed his mental capital in trade.

The advancement of the last fifty years has, I venture to submit, rendered theory and practice so interdependent that an intimate union between them is a matter of absolute necessity for our future progress. Take, for instance, the art of dyeing, and we find that the discovery of new coloring matters derived from waste products, such as coal tar, completely changes its practice, and renders an intimate knowledge of the science of chemistry a matter of absolute necessity to the practitioner. In telegraphy, and in the new arts of applying electricity to lighting, to the transmission of power, and to metallurgical operations, problems arise at every turn, requiring for their solution not only an intimate acquaintance with, but a positive advance upon, electrical science, as established by purely theoretical research in the laboratory. In general engineering, the mere practical art of constructing a machine so designed and proportioned as to produce mechanically the desired effect, would suffice no longer. Our increased knowledge of the nature of the mutual relations between the different forms of energy makes us see clearly what are the theoretical limits of effect; these, although beyond our absolute reach, may be looked upon as the asymptotes to be approached indefinitely by the hyperbolic course of practical progress, of which we should never lose sight. Cases arise, moreover, where the introduction of new materials of construction, or the call for new effects, renders former rules wholly insufficient. In all these cases practical knowledge has to go hand in hand with advanced science in order to accomplish the desired end.

Far be it from me to think lightly of the ardent students of nature, who, in their devotion to research, do not allow their minds to travel into the regions of utilitarianism and of self-interest. These, the high

priests of science, command our utmost admiration; but it is not to them that we can look for our current progress in practical science, much less can we look for it to the "rule of thumb" practitioner, who is guided by what comes nearer to instinct than to reason. It is to the man of science, who also gives attention to practical questions, and to the practitioner, who devotes part of his time to the prosecution of strictly scientific investigations, that we owe the rapid progress of the present day, both merging more and more into one class, that of pioneers in the domain of nature. It is such men that Archimedes must have desired when he refused to teach his disciples the art of constructing his powerful ballistic engines, exhorting them to give their attention to the principles involved in their construction, and that Telford, the founder of the Institution of Civil Engineers, must have had in his mind's eye, when he defined civil engineering as "the art of directing the great sources of power in nature."

These considerations may serve to show that, although we see the men of both abstract and applied science group themselves in minor bodies for the better prosecution of special objects, the points of contact between the different branches of knowledge are ever multiplying, all tending to form part of a mighty tree—the tree of modern science—under whose ample shadow its cultivators will find it both profitable and pleasant to meet, at least once a year; and considering that this tree is not the growth of one country only, but spreads both its roots and branches far and wide, it appears desirable that at these yearly gatherings other nations should be more fully represented than has hitherto been the case. The subjects discussed at our meetings are without exception of general interest, but many of them bear an international character, such as the systematic collection of magnetic, astronomical, meteorological, and geodetical observations, the formation of a universal code for signaling at sea, and for distinguishing lighthouses, and especially the settlement of scientific nomenclatures and units of measurement, regarding all of which an international accord is a matter of the utmost practical importance.

As regards the measures of length and weight it is to be regretted that this country still stands aloof from the movement initiated in France towards the close of last century; but, considering that in scientific work metrical measure is now almost universally adopted, and that its use has been already legalized in this country, I venture to hope that its universal adoption for commercial purposes will soon follow as a

matter of course. The practical advantages of such a measure to the trade of this country would, I am convinced, be very great, for English goods, such as machinery or metal rolled to current sections, are now almost excluded from the continental market, owing to the unit measure employed in their production. The principal impediment to the adoption of the metre consists in the strange anomaly that although it is legal to use that measure in commerce, and although a copy of the standard metre is kept in the Standards' Department of the Board of Trade, it is impossible to procure legalized rods representing it, and to use a non-legalized copy of a standard in commerce is deemed fraudulent. Would it not be desirable that the British Association should endeavor to bring about the use in this country of the metre and kilogram, and, as a preliminary step, petition the government to be represented on the International Metric Commission, whose admirable establishment at Sèvres possesses, independently of its practical work, considerable scientific interest, as a well-found laboratory for developing methods of precise measurement?

Next in importance to accurate measures of length, weight, and time, stand, for the purposes of modern science, those of electricity.

The remarkably clear lines separating conductors from non-conductors of electricity, and magnetic from non-magnetic substances, enable us to measure electrical quantities and effects with almost mathematical precision; and, although the ultimate nature of this, the youngest scientifically investigated form of energy, is yet wrapped in mystery, its laws are the most clearly established, and its measuring instruments (galvanometers, electrometers, and magnetometers) are amongst the most accurate in physical science. Nor could any branch of science or industry be named in which electrical phenomena do not occur, to exercise their direct and important influence.

If, then, electricity stands foremost amongst the exact sciences, it follows that its unit measures should be determined with the utmost accuracy. Yet, twenty years ago very little advance had been made towards the adoption of a rational system. Ohm had, it is true, given us the fixed relations existing between electromotive force, resistance and quantity of current; Joule had established the dynamical equivalent of heat and electricity, and Gauss and Weber had proposed their elaborate system of absolute magnetic measurement. But these invaluable researches appeared only as isolated efforts, when, in 1862, the Electric Unit Committee was appointed by the British Association, at

the instance of Sir William Thomson, and it is to the long-continued activity of this committee that the world is indebted for a consistent and practical system of measurement, which, after being modified in details, received universal sanction last year by the International Electrical Congress assembled at Paris.

At this Congress, which was attended officially by the leading physicists of all civilized countries, the attempt was successfully made to bring about a union between the statical system of measurement that had been followed in Germany and some other countries, and the magnetic or dynamical system developed by the British Association, also between the geometrical measure of resistance, the (Werner) Siemens unit that had been generally adopted abroad, and the British Association unit intended as a multiple of Weber's absolute unit, though not entirely fulfilling that condition. The Congress, while adopting the absolute system of the British Association, referred the final determination of the unit measure of resistance to an International Committee, to be appointed by the representatives of the several governments; they decided to retain the mercury standard for reproduction and comparison, by which means the advantages of both systems are happily combined, and much valuable labor is utilized; only, instead of expressing electrical quantities directly in absolute measure, the Congress has embodied a consistent system, based on the Ohm, in which the units are of a value convenient for practical measurements. In this, which we must hereafter know as the "practical system," as distinguished from the "absolute system," the units are named after leading physicists, the Ohm, Ampère, Volt, Coulomb, and Farad.

I would venture to suggest that two further units might, with advantage, be added to the system decided on by the International Congress at Paris. The first of these is the unit of magnetic quantity or pole. It is of much importance, and few will regard otherwise than with satisfaction tke suggestion of Clausius that the unit should be called a "Weber," thus retaining a name most closely connected with electrical measurements, and only omitted by the Congress in order to avoid the risk of confusion in the magnitude of the unit current with which his name has been formerly associated.

The other unit I should suggest adding to the list is that of power. The power conveyed by a current of an Ampère through the difference of potential of a Volt is the unit consistent with the practical system. It might be appropriately called a Watt, in honor of that master mind

in mechanical science, James Watt. He it was who first had a clear physical conception of power, and gave a rational method of measuring it. A Watt, then, expresses the rate of an Ampère multiplied by a Volt, whilst a horse-power is 746 Watts, and a Cheval de Vapeur 735.

The system of electro-magnetic units would then be:

(1)	Weber,	the unit of	magnetic quantity	$=10^8$	C.G.S. Units.
(2)	Ohm	"	" resistance	$=10^9$	"
(3)	Volt	"	" electromotive force	$=10^8$	"
(4)	Ampère	"	" current	$=10^{-1}$	"
(5)	Coulomb	"	" quantity	$=10^{-1}$	"
(6)	Watt	"	" power	$=10^7$	"
(6)	Farad	"	" capacity	$=10^{-9}$	"

Before the list can be looked upon as complete two other units may have to be added, the one expressing that of magnetic field, and the other of heat in terms of the electro-magnetic system. Sir William Thomson suggested the former at the Paris Congress, and pointed ont that it would be proper to attach to it the name of Gauss, who first theoretically and practically reduced observations of terrestrial magnetism to absolute measure. A Gauss will, then, be defined as the intensity of field produced by a Weber at a distance of one centimetre; and the Weber will be the absolute C.G.S. unit strength of magnetic pole. Thus the mutual force between two ideal point-poles, each of one Weber strength held at unit distance asunder, will be one dyne; that is to say, the force which, acting for a second of time on a gram of matter, generates a velocity of one centimetre per second.

The unit of heat has hitherto been taken variously as the heat required to raise a pound of water at the freezing point through 1° Fahrenheit or Centigrade, or, again, the heat necessary to raise a kilogram of water 1° Centigrade. The inconvenience of a unit so entirely arbitrary is sufficiently apparent to justify the introduction of one based on the electro-magnetic system, viz., the heat generated in one second by the current of an Ampère flowing through the resistance of an Ohm. In absolute measure its value is 10^7 C.G.S. units, and, assuming Joule's equivalent as 42,000,000, it is the heat necessary to raise 0·238 grams of water 1° Centigrade, or, approximately, the $\frac{1}{1000}$ part of the arbitrary unit of a pound of water raised 1° Fahrenheit and the $\frac{1}{4000}$ of the kilogramme of water raised 1° Centigrade. Such a heat unit, if found acceptable, might with great propriety, I

think, be called the Joule, after the man who has done so much to develop the dynamical theory of heat.

Professor Clausius urges the advantages of the statical system of measurement for simplicity, and shows that the numerical values of the two systems can readily be compared by the introduction of a factor, which he proposes to call the critical velocity; this, Weber has already shown to be nearly the same as the velocity of light. It is not immediately evident how by the introduction of a simple multiple, signifying a velocity, the statical can be changed into dynamical values, and I am indebted to my friend Sir William Thomson for an illustration which struck me as remarkably happy and convincing. Imagine a ball of conducting matter so constituted that it can at pleasure be caused to shrink. Now let it first be electrified and left insulated with any quantity of electricity on it. After that, let it be connected with the earth by an excessively fine wire or a not perfectly dry silk fibre; and let it shrink just so rapidly as to keep its potential constant, till the whole charge is carried off. The velocity with which its surface approaches its centre is the electrostatic measure of the conducting power of the fibre. Thus we see how "conducting power" is, in electostatic theory, properly measured in terms of a velocity. Weber had shown how, in electro-magnetic theory, the resistance, or the reciprocal of the conducting power of a conductor, is properly measured by a velocity. The critical velocity, which measures the conducting power in electrostatic reckoning and the resistance in electromagnetic, of one and the same conductor, measures the number of electrostatic units in the electromagnetic unit of electric quantity.

Without waiting for the assembling of the International Committee charged with the final determination of the Ohm, one of its most distinguished members, Lord Rayleigh, has, with his collaborateure, Mrs. Sidgwick, continued his important investigation in this direction at the Cavendish Laboratory, and has lately placed before the Royal Society a result which will probably not be surpassed in accuracy. His redetermination brings him into close accord with Dr. Werner Siemens, their two values of the mercury unit being 0·95418 and 0·9536 of the B.A. unit respectively, or 1 mercury unit $= 0{\cdot}9413 \times 10^9$ C.G.S. units.

Shortly after the publication of Lord Rayleigh's recent results, Messrs. Glazebrook, Dodds, and Sargant, of Cambridge, communicated to the Royal Society two determinations of the Ohm, by different

methods; and it is satisfactory to find that their final values differ only in the fourth decimal, the figures being, according to

Lord Rayleigh, . . 1 Ohm = 0·98651 $\frac{\text{Earth Quadrant.}}{\text{Second.}}$

Messrs. Glazebrook, etc., =0·986439 "

Professor E. Wiedemann, of Leipzig, has lately called attention to the importance of having the Ohm determined in the most accurate manner possible, and enumerates four distinct methods, all of which should unquestionably be tried with a view of obtaining concordant results, because upon its accuracy will depend the whole future system of measurement of energy of whatever form.

The word Energy was first used by Young in a scientific sense, and represents a conception of recent date, being the outcome of the labors of Carnot, Mayer, Joule, Grove, Clausius, Clerk-Maxwell, Thomson, Stokes, Helmholtz, Macquorn-Rankine, and other laborers, who have accomplished for the science regarding the forces in Nature what we owe to Lavoisier, Dalton, Berzelius, Liebig, and others, as regards Chemistry. In this short word Energy we find all the efforts in nature, including electricity, heat, light, chemical action, and dynamics, equally represented, forming, to use Dr. Tyndall's apt expression, so many "modes of motion." It will readily be conceived that when we have established a fixed numerical relation between these different modes of motion we know beforehand what is the utmost result we can possibly attain in converting one form of energy into another, and to what extent our apparatus for effecting the conversion falls short of realizing it. The difference between ultimate theoretical effect and that actually obtained is commonly called loss, but, considering that energy is indestructible, represents really secondary effect which we obtain without desiring it. Thus friction in the working parts of a machine represents a loss of mechanical effect, but is a gain of heat, and in like manner the loss sustained in transferring electrical energy from one point to another is accounted for by heat generated in the conductor. It sometimes suits our purpose to augment the transformation of electrical into heat energy at certain points of the circuit when the heat rays become visible, and we have the incandescence electric light. In effecting a complete severance of the conductor for a short distance, after the current has been established, a very great local resistance is occasioned, giving rise to the electric arc, the highest development of heat ever attained. Vibration is another form of lost

energy in mechanism, but who would call it a loss if it proceeded from the violin of a Joachim or a Norman-Neruda?

Electricity is the form of energy best suited for transmitting an effect from one place to another; the electric current passes through certain substances—the metals—with a velocity limited only by the retarding influence caused by electric charge of the surrounding dielectric, but approaching probably under favorable conditions that of radiant heat and light, or 300,000 kilometres per second; it refuses, however, to pass through oxidized substances, glass, gums, or through gases except when in a highly rarefied condition. It is easy therefore, to confine the electric current within bounds, and to direct it through narrow channels of extraordinary length. The conducting wire of an Atlantic cable is such a narrow channel, it consists of a copper wire, or strand of wires, 5 mm. in diameter, by nearly 5,000 kilometres in length, confined electrically by a coating of guttapercha about 4 mm. in thickness. The electricity from a small galvanic battery passing into this channel prefers the long journey to America in the good conductor, and back through the earth, to the shorter journey across the 4 mm. in thickness of insulating material. By an improved arrangement the alternating currents employed to work long submarine cables do not actually complete the circuit, but are merged in a condenser at the receiving station after having produced their extremely slight but certain effect upon the receiving instrument, the beautiful syphon recorder of Sir William Thomson. So perfect is the channel and so precise the action of both the transmitting and receiving instruments employed, that two systems of electric signals may be passed simultaneously through the same cable in opposite directions, producing independent records at either end. By the application of this duplex mode of working to the direct United States cable under the superintendence of Dr. Muirhead, its transmitting power was increased from twenty-five to sixty words a minute, being equivalent to about twelve currents or primary impulses per second. In transmitting these impulse-currents simultaneously from both ends of the line, it must not be imagined, however, that they pass each other in th manner of liquid waves belonging to separate systems; such a suppositon would involve momentum in the electric flow, and although the effect produced is analagous to such an action, it rests upon totally different grounds—namely, that of a local circuit at each terminus being called into action automatically whenever two similar currents are passed into the line simultaneously

from both ends. In extending this principle of action quadruplex telegraphy has been rendered possible, although not yet for long submarine lines.

The minute currents here employed are far surpassed as regards delicacy and frequency by those revealed to us by that marvel of the present day, the telephone. The electric currents caused by the vibrations of a diaphragm acted upon by the human voice naturally vary in frequency and intensity according to the number and degree of those vibrations, and each motor current in exciting the electromagnet forming part of the receiving instrument, deflects the iron diaphragm occupying the position of an armature to a greater or smaller extent according to its strength. Savart found that the fundamental *la* springs from 440 complete vibrations in a second, but what must be the frequency and modulations of the motor current and of magnetic variations necessary to convey to the ear through the medium of a vibrating armature such a complex of human voices and of musical instruments as constitutes an opera performance. And yet such performances could be distinctly heard and even enjoyed as an artistic treat by applying to the ears a pair of the double telephonic receivers at the Paris Electrical Exhibition, when connected with a pair of transmitting instruments in front of the footlights of the Grand Opera. In connection with the telephone, and with its equally remarkable adjunct, the microphone, the names of Riess, Graham Bell, Edison, and Hughes will ever be remembered.

Considering the extreme delicacy of the currents working a telephone, it is obvious that those caused by induction from neighboring telegraphic line wires would seriously interfere with the former, and mar the speech or other sounds produced through their action. To avoid such interference the telephone wires if suspended in the air require to be placed at some distance from telegraphic line wires, and to be supported by separate posts. Another way of neutralizing interference consists in twisting two separately insulated telephone wires together so as to form a strand, and in using the two conductors as a metallic circuit to the exclusion of the earth; the working current will, in that case receive equal and opposite inductive influences, and will therefore remain unaffected by them. On the other hand, two insulated wires instead of one are required for working one set of instruments, and a serious increase in the cost of installation is thus caused. To avoid this Mr. Jacob has lately suggested a plan of combining

pairs of such metallic circuits again into separate working pairs, and these again with other working pairs, whereby the total number of telephones capable of being worked without interference is made to equal the total number of single wires employed. The working of telephones and telegraphs in metallic circuit has the further advantage that mutual volta induction between the outgoing and returning currents favors the transit, and neutralizes on the other hand the retrading influence caused by charge in underground or submarine conductors. These conditions are particularly favorable to underground line wires, which possess other important advantages over the still prevailing overground system, in that they are unaffected by atmospheric electricity, or by snow storms and heavy gales, which at not very rare intervals of time put us back to pre-telegraphic days, when the letter carrier was our swiftest messenger.

The undergroung system of telegraphs, first introduced into Germany by Werner Siemens in the years 1847–8, had to yield for a time to the overground system owing to technical difficulties, but it has been again resorted to within the last four years, and multiple land cables of solid construction now connect all the important towns of that country. The first cost of such a system is no doubt considerable, being about 38*l.* per kilometre of conductor as against 8*l.* 10*s.* the cost of land lines); but as the underground wires are exempt from frequent repairs and renewals, and as they insure continuity of service, they are decidedly the cheaper and better in the end. The experience afforded by the early introduction of the underground system in Germany was not, however, without its beneficial results, as it brought to light the phenomena of lateral induction, and of faults in the insulating coating, matters which had to be understood before submarine telegrephy could be attempted with any reasonable prospect of success.

Regarding the transmission of power to a distance, the electric current has now entered the lists in competition with compressed air, the hydraulic accumulator, and the quick running rope as used at Schaffhausen to utilize the power of the Rhine fall. The transformation of electrical into mechanical energy can be accomplished with no further loss than is due to such incidental causes as friction and the heating of wires; these in a properly designed dynamo-electric machine do not exceed ten per cent., as shown by Dr. John Hopkinson, and, judging from recent experiments of my own, a still nearer approach to ultimate perfection is attainable. Adhering, however, to Dr. Hopkin-

son's determination for safety's sake, and assuming the same percentage in reconverting the current into mechanical effect, a total loss of 19 per cent. results. To this loss must be added that through electrical resistance in the connecting line wires, which depends upon their length and conductivity, and that due to heating by friction of the working parts of the machine. Taking these as being equal to the internal losses incurred in the double process of conversion, there remains a useful effect of 100—38=62 per cent. attainable at a distance, which agrees with experimental results, although in actual practice it would not be safe at present to expect more than 50 per cent. of ultimate useful effect, to allow for all mechanical losses.

In using compressed air or water for the transmission of power the loss cannot be taken at less than fifty per cent., and as it depends upon fluid resistance it increases with distance more rapidly than in the case of electricity. Taking the loss of effect in all cases as 50 per cent. electric transmission presents the advantage that an insulated wire does the work of a pipe capable of withstanding high internal pressure, which latter must be more costly to put down and to maintain. A second metallic conductor is required, however, to complete the electrical circuit, as the conducting power of the earth alone is found unreliable for passing quantity currents, owing to the effects of polarization; but as this second conductor need not be insulated, water or gas pipes, railway metals or fencing wire, may be called into requisition for the purpose. The small space occupied by the electro-motor, its high working speed, and the absence of waste products, render it specially available for the general distribution of power to cranes and light machinery of every description. A loss of effect of 50 per cent. does not stand in the way of such applications, for it must be remembered that a powerful central engine of best construction produces motive power with a consumption of two pounds of coal per horse-power per hour, whereas small engines distributed over a district would consume not less than five; we thus see that there is an advantage in favour of electric transmission as regards fuel, independently of the saving of labor and other collateral benefits.

To agriculture electric transmission of power seems well adapted for effecting the various operations of the farm and fields from one centre. Having worked such a system myself in combination with electric lighting and horticulture for upwards of two years, I can speak with

confidence of its economy, and of the facility with which the work is accomplished in charge of untrained persons.

As regards the effect of the electric light upon vegetation there is little to add to what was stated in my paper read before Section A last year, and ordered to be printed with the report, except that in experimenting upon wheat, barley, oats, and other cereals sown in the open air, there was a marked difference between the growth of the plants influenced and those uninfluenced by the electric light. This was not very apparent till towards the end of February, when, with the first appearance of mild weather, the plants under the influence of an electric lamp of 4000 candle power placed about 5 metres above the surface, developed with extreme rapidity, so that by the end of May they stood above 4 feet high, with the ears in full bloom, when those not under its influence were under 2 feet in height, and showed no sign of the ear.

In the electric railway first constructed by Dr. Werner Siemens, at Berlin, in 1879, electric energy was transmitted to the moving carriage or train of carriages through the two rails upon which it moved, these being sufficiently insulated from each other by being placed upon well creosoted cross sleepers. At the Paris Electrical Exhibition the current was conveyed through two separate conductors making sliding or rolling contact with the carriage, whereas in the electric railway now in course of construction in the north of Ireland (which when completed will have a length of twelve miles) a separate conductor will be provided by the side of the railway, and the return circuit completed through the rails themselves, which in that case need not be insulated; secondary batteries will be used to store the surplus energy created in running downhill, to be restored in ascending steep inclines, and for passing roadways where the separate insulated conductor is not practicable. The electric railway possesses great advantages over horse or steam-power for towns, in tunnels, and in all cases where natural sources of energy, such as waterfalls, are available; but it would not be reasonable to suppose that it will in its present condition compete with steam propulsion upon ordinary railways. The transmission of power by means of electric conductors possesses the further advantage over other means of transmission that, provided the resistance of the rails be not very great, the power communicated to the locomotive reaches its maximum when the motion is at its minimum—that is, in commencing to work, or when encountering an exceptional resistance—whereas the

utmost economy is produced in the normal condition of working when the velocity of the power-absorbing nearly equals that of the current-producing machine.

The deposition of metals from their solutions is perhaps the oldest of all useful applications of the electric current, but it is only in very recent times that the dynamo current has been practically applied to the refining of copper and other metals, as now practised at Birmingham and elsewhere, and upon an exceptionally large scale at Ocker, in Germany. The dynamo machine there employed was exhibited at the Paris Electrical Exhibition by Dr. Werner Siemens, its peculiar feature being that the conductors upon the rotating armature consisted of solid bars of copper 30 mm. square in section, which were found only just sufficient to transmit the large quantity of electricity of low tension necessary for this operation. One such machine consuming 4 horse-power deposits about 300 kilogrammes of copper per 24 hours; the motive power at Ocker is derived from a waterfall.

Electric energy may also be employed for heating purposes, but in this case it would obviously be impossible for it to compete in point of economy with the direct combustion of fuel for the attainment of ordinary degrees of heat. Bunsen and St. Claire De Ville have taught us, however, that combustion becomes extremely sluggish when a temperature of 1800°C. has been reached, and for effects at temperatures exceeding that limit the electric furnace will probably find advantageous applications. Its specific advantage consists in being apparently unlimited in the degree of heat attainable, thus opening out a new field of investigation to the chemist and metallurgist. Tungsten has been melted in such a furnace, and 8 pounds of platinum have been reduced from the cold to the liquid condition in 20 minutes.

The largest and most extensive application of electric energy at the present time is to lighting, but considering how much has of late been said and written for and against this new illuminant, I shall here confine myself to a few general remarks. Joule has shown that if an electric current is passed through a conductor the whole of the energy lost by the current is converted into heat; or, if the resistance be localized, into radiant energy comprising heat, light, and actinic rays. Neither the low heat rays nor the ultra-violet of highest refrangibility affect the retina, and may be regarded as lost energy, the effective rays being those between the red and violet of the spectrum, which in their combination produce the effect of white light.

Regarding the proportion of luminous to non-luminous rays proceeding from an electric arc or incandescent wire, we have a most valuable investigation by Dr. Tyndall, recorded in his work on "Radiant Heat." Dr. Tyndall shows that the luminous rays from a platinum wire heated to its highest point of incandescence, which may be taken at 1700°C., formed $\frac{1}{24}$ part of the total radiant energy emitted, and $\frac{1}{10}$ part in the case of an arc light worked by a battery of 50 Grove's elements. In order to apply these valuable data to the case of electric lighting by means of dynamo-currents, it is necessary in the first place to determine what is the power of 50 Grove's elements of the size used by Dr. Tyndall, expressed in the practical scale of units as now established. From a few experiments, lately undertaken for myself, it would appear that 50 such cells have an electro-motive force of 98·5 Volts, and an internal resistance of 13·5 Ohms, giving a current of 7·3 Ampères when the cells are short-circuited. The resistance of a regulator such as Dr. Tyndall used in his experiments may be taken at 10 Ohms, the current produced in the arc would be $\frac{98{\cdot}5}{13{\cdot}5+10+1} = 4$ Ampères (allowing one Ohm for the leads), and the power consumed $10\times4^2 = 160$ Watts; the light power of such an arc would be about 150 candles, and, comparing this with an arc of 3308 candles produced by 1162 Watts, we find that $\left(\frac{1162}{160}\right)$, *i. e.*, 7·3 times the electric energy produce $\left(\frac{3308}{150}\right)$, *i. e.*, 22 times the amount of light measured horizontally. If, therefore, in Dr. Tyndall's arc $\frac{1}{10}$ of the radiant energy emitted was visible as light, it follows that in a powerful arc of 3300 candles, $\frac{1}{10}\times\frac{22{\cdot}0}{7{\cdot}3}$, or fully $\frac{1}{3}$, are luminous rays. In the case of the incandescence light (say a Swan light of 20 candle power) we find in practice that 9 times as much power has to be expended as in the case of the arc light; hence $\frac{1}{3}\times\frac{1}{9} = \frac{1}{27}$ part of the power is given out as luminous rays, as against $\frac{1}{24}$ in Dr. Tyndall's incandescent platinum—a result sufficiently approximate considering the wide difference of conditions under which the two are compared.

These results are not only of obvious practical value, but they seem to establish a fixed relation between current, temperature, and light produced, which may serve as a means to determine temperatures exceeding the melting point of platinum with greater accuracy than has hith-

erto been possible by actinimetric methods in which the thickness of the luminous atmosphere must necessarily exercise a disturbing influence. It is probably owing to this circumstance that the temperature of the electric arc as well as that of the solar photosphere has frequently been greatly over-estimated.

The principal argument in favor of the electric light is furnished by its immunity from products of combustion which not only heat the lighted apartments, but substitute carbonic acid and deleterious sulphur compounds for the oxygen upon which respiration depends; the electric light is white instead of yellow, and thus enables us to see pictures, furniture, and flowers as by daylight; it supports growing plants instead of poisoning them, and by its means we can carry on photography and many other industries at night as well as during the day. The objection frequently urged against the electric light, that it depends upon the continuous motion of steam or gas engines, which are liable to accidental stoppage, has been removed by the introduction into practical use of the secondary battery; this, although not embodying a new conception, has lately been greatly improved in power and constancy by Planté, Faure, Volckmar, Sellon, and others, and promises to accomplish for electricity what the gas-holder has done for the supply of gas and the accumulator for hydraulic transmission of power.

It can no longer be a matter of reasonable doubt, therefore, that electric lighting will take its place as a public illuminant, and that even though its cost should be found greater than that of gas, it will be preferred for the lighting of drawing-rooms and dining-rooms, theatres and concert-rooms, museums, churches, warehouses, show rooms, printing establishments and factories, and also the cabins and engine-rooms of passenger steamers. In the cheaper and more powerful form of the arc light it has proved itself superior to any other illuminant for spreading artificial daylight over the large areas of harbors, railway stations, and the sites of public works. When placed within a holophote the electric lamp has already become a powerful auxiliary in effecting military operations both by sea and land.

The electric light may be worked by natural sources of power such as waterfalls, the tidal wave, or the wind, and it is conceivable that these may be utilized at considerable distances by means of metallic conductors. Some five years ago I called attention to the vastness of those sources of energy, and the facility offered by electrical conduction in rendering them available for lighing and power-supply, while Sir

William Thomson made this important matter the subject of his admirable address to Section A last year at York, and dealt with it in an exhaustive manner.

The advantages of the electric light and of the distribution of power by electricity have lately been recognized by the British government, who have just passed a bill through parliament to facilitate the establishment of electrical conductors in town, subject to certain regulating clauses to protect the interests of the public and of local authorities. Assuming the cost of electric light to be practically the same as gas, the preference for one or other will in each application be decided upon grounds of relative convenience, but I venture to think that gas-lighting will hold its own as the poor man's friend.

Gas is an institution of the utmost value to the artisan; it requires hardly any attention, is supplied upon regulated terms, and gives with what should be a cheerful light a genial warmth, which often saves the lighting of a fire. The time is moreover not far distant, I venture to think, when both rich and poor will largely resort to gas as the most convenient, the cleanest, and the cheapest of heating agents, and when raw coal will be seen only at the colliery or the gas works. In all cases where the town to be supplied is within say 30 miles of the colliery, the gas works may with advantage be planted at the mouth, or still better at the bottom of the pit, whereby all haulage of fuel would be avoided, and the gas, in its ascent from the bottom of the colliery, would acquire an onward pressure sufficient probably to impel it to its destination. The possibility of transporting combustible gas through pipes for such a distance has been proved at Pittsburg, where natural gas from the oil district is used in large quantities.

The quasi monopoly so long enjoyed by gas companies has had the inevitable effect of checking progress. The gas being supplied by meter, it has been seemingly to the advantage of the companies to give merely the prescribed illuminating power, and to discourage the invention of economical burners, in order that the consumption might reach a maximum. The application of gas for heating purposes has not been encouraged, and is still made difficult in consequence of the objectionable practice of reducing the pressure in the mains during day-time to the lowest possible point consistent with prevention of atmospheric indraught. The introduction of the electric light has convinced gas managers and directors that such a policy is no longer tenable, but must give way to one of technical progress; new processes for cheap-

ening the production and increasing the purity and illuminating power of gas are being fully discussed before the Gas Institute; and improved burners, rivaling the electric light in brilliancy, greet our eyes as we pass along our principal thoroughfares.

Regarding the importance of the gas supply as it exists at present, we find from a government return that the capital invested in gas works in England, other than those of local authorities, amounts to 30,000,000*l.*; in these 4,281,048 tons of coal are converted annually, producing 43,000 million cubic feet of gas, and about 2,800,000 tons of coke; whereas the total amount of coal annually converted in the United Kingdom may be estimated at 9,000,000 tons, and the by-products therefrom at 500,000 tons of tar, 1,000,000 tons of ammonia liquor, and 4,000,000 tons of coke, according to the returns kindly furnished me by the managers of many of the gas works and corporations. To these may be added say 120,000 tons of sulphur, which up to the present time is a waste product.

Previous to the year 1856—that is to say, before Mr. W. H. Perkin had invented his practical process, based chiefly upon the theoretical investigations of Hoffman, regarding the coal-tar bases and the chemical constitution of indigo—the value of coal-tar in London was scarcely a half-penny a gallon, and in country places gas-makers were glad to give it away. Up to that time the coal-tar industry had consisted chiefly in separating the tar by distillation into naphtha, creosote, oils, and pitch. A few distillers, however, made small quantities of benzene, which had been first shown—by Mansfield, in 1849—to exist in coal-tar naphtha mixed with toluene, cumene, etc. The discovery, in 1856, of the mauve or aniline purple gave a great impetus to the coal-tar trade, inasmuch as it necessitated the separation of large quantities of benzene, or a mixture of benzene and toluene, from the naphtha. The trade was further increased by the discovery of the magenta or rosaniline dye, which required the same products for its preparation. In the meantime, carbolic acid was gradually introduced into commerce, chiefly as a disinfectant, but also for the production of coloring matter.

The next most important development arose from the discovery by Græbe and Liebermann that alizarine, the coloring principle of the madder root, was allied to anthracene, a hydrocarbon existing in coal-tar. The production of this coloring matter from anthracene followed, and is now one of the most important operations connected with tar

distilling. The success of the alizarine made in this manner has been so great that it has almost entirely superseded the use of madder, which is now cultivated to only a comparatively small extent. The most important coloring matters recently introduced are the azo-scarlets. They have called into use the coal-tar hydrocarbons, xylene and cumene. Napthalene is also used in their preparation. These splendid dyes have replaced cochineal in many of its applications, and have thus seriously interfered with its use. The discovery of artificial indigo by Professor Baeyer is of great interest. For the preparation of this coloring matter toluene is required. At present artificial indigo does not compete seriously with the natural product; but should it eventually be prepared in quantity from toluene a further stimulus will be given to the coal-tar trade.

The color industry utilizes even now practically all the benzene, a large proportion of the solvent naphtha, all the anthracene, and a portion of the naphthaline resulting from the distillation of coal-tar; and the value of the coloring matter thus produced is estimated by Mr. Perkin at 3,350,000*l.*

(To be continued.)

THE CHEMISTRY OF THE PLANTÉ AND FAURE ACCUMULATORS.*

By J. H. Gladstone and Alfred Tribe.

Part IV.—The Function of Sulphate of Lead.

In our previous communications on the chemistry of the lead and peroxide batteries we have frequently remarked on the formation of lead sulphate and its importance in the history of a cell.

In Part I (this journal, vol. cxiv, p. 219) we showed that the local action that takes place at first energetically between the metallic lead and the peroxide is gradually diminished by the formation of sulphate of lead.

In Part II (vol. cxiv, p. 223) we stated that in the original formation of a Faure cell, sulphate of lead is oxidated on the one plate and reduced on the other. We also described an experiment in which two platinum plates were covered with lead-sulphate, immersed in dilute

* London *Nature*, Oct. 19, 1882.

sulphuric acid, and placed in the circuit of a galvanic current; the result being that "the white sulphate was decomposed to a large extent on each plate, the positive being covered with deep chocolate-colored peroxide, the negative with gray spongy lead."

In Part III (vol. cxiv, p. 229) we showed that on the discharge of a cell, lead sulphate is the ultimate product on both plates.

It might naturally be inferred from our previous statements that in the recharging of a cell this lead sulphate would be oxidated on the one plate and reduced on the other as in the original formation. This matter, however, has given rise to some controversy. All subsequent experimenters admit the *oxidation* of the lead-sulphate, but Dr. Oliver Lodge could not obtain any reduction of it when pure sulphate was employed. Sir William Thomson also, when experimenting, with two platinum plates and layers of sulphate, obtained only a doubtful indication of reduced metal. The question as to whether the sulphate is reduced or not, on recharging a Faure cell is one of vital importance; for if the sulphate formed at each discharge accumulates on the positive plate it would clog up the space, and, what is perhaps worse, a fresh surface of the lead would have to be oxidated (or rather, converted into sulphate) at each discharge. Thus the positive plate will be continually corroded, and its life will be limited.

We have already replied to Dr. Lodge in *Nature* (vol. xxvi, p. 342), but we thought it desirable to repeat the experiment with the platinum plates, especially with a view to determine whether the reduction was effected slowly or with any rapidity. We fastened 20 grammes of the white sulphate upon a negative plate by binding it round tightly with parchment-paper, placed it vertically in the sulphuric acid, and passed a continuous current of somewhat under an Ampère. The hydrogen was at no time wholly absorbed—indeed the greater part of it certainly escaped—but after the lapse of twenty-four hours, small patches of gray metallic lead became distinctly visible through the wet parchment-paper; and these gradually spread in an irregular manner. At the end of ten days it was found that the whole of the sulphate, except a few small patches on the surface, was reduced to a gray spongy mass. Although there could be no reasonable doubt that this was metallic lead, a portion of it was tested chemically, and proved to be such.

It thus appears that the *reduction* of the pure sulphate of lead is an absolute fact, although it does not take place so easily as the oxidation.

In an actual cell the sulphate of lead is of course mixed with other

bodies. Thus, in the formation of a Faure battery, the minium is converted by the sulphuric acid more or less completely into peroxide of lead and sulphate. We have already described an experiment in which 4489 cc. of hydrogen were absorbed on a plate, the materials of which were capable of absorbing only 4574 cc., if the whole sulphate as well as the peroxide was reduced. In our note-book we have the particulars of four other experiments made in each case with the same, or nearly the same, amount of material, in which 4199, 4575, 4216, and 4387 cc. respectively were absorbed, although perhaps in not one of these cases was the experiment continued until the action was absolutely complete. As, however, it may be objected that the amount of sulphate produced upon these plates was an unknown quantity, we have in a recent experiment treated the minium in the first instance with a considerable amount of sulphuric acid. This gave us a mixture which, on analysis, was found to contain 18·5 per cent. of sulphate of lead. This mixture when submitted to the reducing action of a current yielded a mass of spongy lead that contained only a mere trace of sulphate.

As it seemed desirable fully to establish the fact that the sulphate of lead formed on the discharge of a cell is reduced in the subsequent charging, we took the quondam lead plate of a fully discharged cell, determined the proportion of sulphate to unaltered spongy lead, and submitted it to the reducing action of a current. The amount of sulphate on the plate before passing the current was found to be 51 per cent., but, after the passage of a current, of about an ampère for 60 hours, not a trace of it remained.

Hence it may be concluded that, during the alternate discharging and recharging of a Planté or Faure cell, sulphate of lead is alternately formed and reduced on the lead plate, and that the plate itself is not seriously corroded. It would, however, appear desirable not to allow the whole of the spongy lead to be reduced to sulphate during the discharge for two reasons, viz.: (1) because the supporting plate stands a chance of being itself acted on if there is not a sufficient excess of spongy metal; and (2) because the presence of this excess tends to facilitate the reduction of the sulphate.

We have already shown that sulphate of lead is produced by the local action that takes place between the peroxide and its supporting lead plate during repose. The same local action also takes place during the charging of the plate, as was pointed out in our second

communication, and this sulphate is, in its turn, attacked by the electrolytic oxygen. In this way the absorption of oxygen in forming the negative plate ought never to come to an end. In order to see whether this was the case, we allowed an experiment to continue for 115 hours, although the main action was over in about 40 hours. For the last two days of the experiment, the amount of oxygen absorbed was pretty constant, being about 9 cc. per hour, which is equivalent to 0·24 grammes of sulphate of lead formed and oxidated. The whole charge on the plate was 40 grammes of peroxide. This local action also takes place during the discharge, as is evidenced by the sulphate of lead formed on the negative plate always exceeding in amount that formed on the positive plate.

Through this local action taking place during the formation of the cell, during repose, and during the discharge, the lead plate which supports the peroxide must be continually corroded more and more; and it is probably due to the insolubility of the sulphate formed that the destruction of this kind of secondary battery is so materially retarded in practice.

Contribution of Astronomy to the Solution of a Molecular Problem.—Pictet's consideration of the temperature of a body as resulting from the mean amplitude of its molecular oscillations enables him to explain and deduce all the essential laws of thermodynamics, Dulong and Petit's law, the law of isomorphism in systems of crystallization, the relations which unite coefficients of dilatation with atomic weight, etc. Under this view, specific heat becomes the manifestation of the attraction of molecules for one another; by multiplying the space traversed (temperature) by the molecular force (specific heat) we obtain the total heat or absolute quantity of work which the body contains. Hence, consequently, arises a question of the first importance: Is the mutual attraction of particles of matter a fundamental and essential property of matter itself, or is it only the result of dynamic action of the medium in which it is found? Pictet suggests various astronomical observations which seem likely to contribute to a solution of this question. [Chase's discovery of the velocity of light in the coefficient of solar torsion (*Proc. Am. Phil. Soc.*, April 21, 1882, note 162) points to the photodynamic action of the æthereal medium.]—*Ann. de Chim. et de Phys.*, April, 1882.

The Electric Arc in Vapor of Sulphuret of Carbon.—Jamin and Maneuvrier introduced a few drops of sulphuret of carbon into Geissler tubes, so as slightly to increase the pressure, and thus obtained a light of great brilliancy. On looking at it with smoked glass, they saw a brilliant arc resembling a horse-shoe or a capital omega. The points of the two carbons appeared red and very brilliant; but the arc was of a pale green, and as its light surpassed that of the carbons, the whole hall was illuminated with its tint as it would have been by a copper Bengal light. The brilliancy increased with the increasing tension of the vapor, until it became intolerable; but as the resistance increased at the same time, the arc was often extinguished, and it was necessary frequently to renew it by bringing the two carbons together. It is not likely that the light can be advantageously used, unless for light-houses or signals at a distance.—*Comptes Rendus*, xcv, 6. C.

Surface Temperatures in Paris.—Edmond and Henri Becquerel have presented to the French Academy their observations upon the temperatures of the air and earth during the year 1880. They find that at the upper surface of the ground, when covered with snow, the temperature was maintained almost constantly in the neighborhood of —1°C. and did not fall below—1·5°, although the temperature of the air as well as that of the upper surface of the snow varied from—15° to 0°. The diurnal variations of temperature at the surface of the soil were perceptible under a mass of snow of ·25 metre thickness (9·84 inches), but they never exceed a few tenths of a degree; moreover, the differences in the observed temperatures at different depths in the snow varied nearly in proportion to the depth. These results show that a bed of snow, when the temperature is below 0°C. has a feeble conductivity and behaves like a conducting body traversed by a calorific wave. Under a surface which is covered by turf the variations are much more feeble than under a surface of gravel or loam. The network of rootlets constitutes an almost complete non-conductor. Each bed of soil is submitted to the influence of two calorific effects; one due to the variations of external temperature, the other to the action of the deep layers which tend to produce a constant temperature. The amplitude of thermometric oscillation which results from these complex effects when there is any disturbing influence, such as an infiltration of water, varies inversely with the depth of the bed.—*Comptes Rendus.* C.

The Stone Age in China.—The annals of the Tung dynasty, which was established A. D. 618, speak of stone axes, knives and swords. The annals of the Youen dynasty (A. D. 1260 to 1341) mention soldiers who used stone arrows in fighting. In a Chinese dictionary which was published in 1726 arrows are also spoken of which were pointed by a black stone. Stone arrows were sent to the Emperor Hou Hang, B. C. 1100, and the Chinese books speak of some knives and hatchets of a still greater antiquity.—*Les Mondes*, xxxi, 626. C.

Hydrodynamic Imitation of Electric Phenomena.—Decharme compares the experiments of Bjerknes upon hydro-electricity and hydromagnetism with some observations of his own, in which he substitutes liquid currents, continuous or interrupted, for pulsating or vibrating bodies. By various ingenious contrivances he produces hydro-electro magnets with continuous or discontinuous currents, hydrodynamic vibrations, hydo-electro magnets with similar or with contrary poles and with single or with multiple nuclei manifesting all the phenomena of attraction, repulsion, vibratory movement, hydro-induction and the action of currents upon each other.—*Ann. de Chim. et de Phys.*, April, 1882.

Widening of the Hydrogen Rays.—Lockyer and most astronomers attribute the widening of the spectral rays of hydrogen to the influence of pressure, while others, among whom was Secchi, think that the phenomenon is influenced both by pressure and by temperature. Cailletet, in experimenting upon hydrogen with the electric spark, found that the spectral rays varied somewhat in proportion to the pressure. But as the temperature of the spark increases with the pressure his experiments were inconclusive. The same may be said of the tubes filled with rarefied hydrogen, which were employed by Plücker, Hittorf, Secchi, Wüllner, etc. At a certain pressure, which was differently estimated by each observer, the rays broaden, and they become wider still if the tube is traversed by the spark of the Leyden jar, the temperature of which is more elevated. D. von Monckhoven reports a summary of numerous and varied experiments, from which he draws the conclusion that the widening of the rays is absolutely independent of the temperature and is due solely to the pressure.—*Comptes Rendus*, xcv, 378. C.

Franklin Institute.

HALL OF THE INSTITUTE, December 20, 1882.

The stated meeting of the Institute was held this evening at the usual hour, with the President, Mr. Wm. P. Tatham, in the chair.

There were present 208 members and 40 visitors.

The minutes of the last stated meeting were read and approved.

The Actuary submitted the miuutes of the Board of Managers, and reported that at the stated meeting held December 13th 11 persons had been elected as members. He likewise reported the resignation of Mr. Frederick Fraley as Treasurer of the Institute, to take effect upon the installation of his successor after the annual election in January, 1883.

Mr. Wm. V. McKean, thereupon, after alluding in very complimentary terms to the long and faithful service of Mr. Fraley, offered the following resolutions, which were seconded by Mr. Hector Orr, with appropriate remarks, viz.:

Resolved by the Franklin Institute, December 20, 1882:

1. That the Institute hears with very great regret the resignation by FREDERICK FRALEY of the office of Treasurer, to which he was first elected in 1830, and the duties of which he has discharged with marked ability, zeal and fidelity for thirty-six of the intervening fifty-two years.

2. That the Institute accepts the resignation of Mr. Fraley, and tenders to him this expression of the gratitude and thanks of its memmers for his labors of love of so many years, and their best wishes for his enjoyment of many years to come.

3. That the Board of Managers be requested to have these resolutions engrossed and presented to Mr. Fraley.

The above resolutions were unanimously adopted.

The Actuary also read a letter from Mr. W. F. Dubois, resigning his membership in the Board of Managers. An election was thereupon held to fill the vacancy, which resulted in the choice of Dr. Isaac Norris.

Upon the call for reports from Standing Committees, the Secretary reported from the Committee on Science and the Arts, that the Committee had recommended the award of a Certificate of Merit to Alfred Wilkinson for his Metallic Piston Rod Packing, and to Wm. R.

Fowler for his Cloth Cutting Machine. The award was, in both cases, approved.

Mr. Wm. V. McKean, from the Committee on Sections, made the following report:

Hall of the Franklin Institute, December 18, 1882.

A meeting of the Committee on "Sections" was held this date at the Hall. Present: Messrs. Marks, Thorne, and McKean.

After discussion, it was resolved to recommend that "Sections" be instituted as follows:

(1) Sanitary Engineering—with special reference to household plumbing and drainage, and connecting private and public sewerage.

(2) Ventilation—with the view of correcting wastage of fuel for heating purposes; the withdrawing of damaging currents of cold air; and the injurious effects produced in some instances in the sick chamber, and in hospital wards, by the upward draught of noxious matter.

(3) Road Making—with reference to the paving of cities, and especially for suggestions of improvement in the paving of Philadelphia.

W. V. McKean,
Chairman Committee on Sections.

The following nominations were made for officers, to be chosen at the annual election in January: President, Wm. P. Tatham; Vice President, Frederick Graff; Secretary, Dr. Wm. H. Wahl; Treasurer, Samuel Sartain; Managers, E. J. Houston, William H. Thorne, Persifor Frazer, Enoch Lewis, William Helme, C. H. Banes, John J. Weaver, Frederick Fraley, James Dougherty, G. Morgan Eldridge; Auditor, Wm. A. Cheyney.

The Secretary's report embraced the following noteworthy novelties:

Sleeman's Gas Governor, exhibited by the Philadelphia Gas Saving Company. The device is a meter governor, as distinguished from a burner governor, and is intended to automatically regulate the pressure of gas so as to prevent blowing and waste of gas, while at the same time insuring a more steady and uniform flame. The governor, for actual use, is made of brass, with a balance valve and float sealed in glycerine. In addition to the brass governor, one made of glass was exhibited that its operations might be seen. A gauge was also provided whereby it was shown that the pressure was maintained as nearly as possible constant, no matter whether one or a dozen burners were in use.

The Chamberlain Automatic Pressureo-gverning Gas Burner was also shown. It has an arrangement of a floating valve in the burner, whereby the pressure at the tip of the burner is kept constant, notwithstanding variations of pressure in the main.

Samples of Loiseau's patent fuel were exhibited, and the Secretary stated that the fuel is now being successfully manufactured at the company's works at Port Richmond, and that the demand exceeds the capacity of the works. It is made into egg-shaped lumps, anthracite coal dust being mixed with a small quantity of bituminous coal dust and coal tar pitch.

Wm. T. McRae's friction clutch, the Monitor Heat and Gas Regulator, samples of silk from Nellie Lincoln Rossiter, and John G. Avery's Multiple Wire Belting for sewing machines and other machinery, Charles Kennedy's Belt Fastener, etc., were also exhibited.

Mr. Hugo Bilgram showed two-gear wheels, made by a machine, the principles of which he described before the Institute about a year ago, when he exhibited an odontograph for laying out gear wheels. He stated at the time that it could be easily adapted to cut the teeth automatically, and he has since constructed the machine, which he states produces theoretically perfect gear wheels that gear together as perfectly as the limitations upon the absolute accuracy of machinery will permit.

Blodgett Bros. & Co. exhibited an electric signal clock, now in use in the stations of the New York and New England, and Boston and Albany railroads for signaling the time of the departure of trains. An upright cylinder of brass contains 1440 holes arranged on 24 spirals (one for each hour). Brass pegs are put into the holes representing the minute when a gong is to be sounded. Through these pegs connection is made with an electrical circuit, which is thus completed and brings into play an electro-magnet, whereby the gong is sounded. Arrangement is made for a change of time on Sunday, which is worked automatically. The apparatus was shown at work, and gave a satisfactory performance. Two forms of the same device were shown. They were connected with Mr. Spellier's standard clock, used at the Institute for operating his Time Telegraph.

Chambers' Bros. brick machine, as recently improved, was exhibited, making bricks one-fourth the size of a Philadelphia brick. It has a sanding box, recently added, which sands the bar of clay as it issues from the mould, before it is cut to brick lengths.

Mr. Chambers gave an interesting description of the practical difficulties overcome in adapting the machinery to work all kinds of clay, just as it comes from the bank. The machinery is entirely automatic. Clay is fed into a hopper, and without further handling comes out on an endless traveling belt a perfectly moulded and sanded brick, ready to be dried and baked.

Mr. Chambers also exkibited samples of brick of various forms, and some of them made with large admixture of iron ore, and displayed on the screen diagrams of machines similar to those for brick making, intended to be employed in moulding artificial fuel in any desired form. He also stated that one of the machines was employed with excellent results at Lebanon in compressing iron ore that in its natural state would clog the furnaces, but can be used to good advantage if first moulded into bricks of convenient form.

The meeting was thereupon adjourned.

WILLIAM H. WAHL, *Secretary.*

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